

REVERSE AUCTION BIDDING – IMPACT OF PERSONALITY TYPE ON
BIDDING STRATEGY AND PROFIT

A Thesis

by

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ABSTRACT

This research into Reverse Auction Bidding (RAB) is the first of the twenty four studies completed to this time to use an individual with personality type Idealist specifically against other personality types. Amongst all studies, result of one of the previous studies showed that personality type Idealist won over personality type Guardian and it was the first where this unexpected result was observed. This study attempts to verify the previous finding that an Idealist performs better than a Guardian, as Guardians are the usual winners.

RAB is a new form of bidding using internet as the bidding tool. In RAB the buyer and a set of sellers adopt a slightly different role than in Forward Auction.

This study used four students from the Department of Construction Science at Texas A&M University as the subjects of the work. Specific details of the game are that each bidder has capacity to bid on three jobs at any time. All bidders initially have a bank amount of \$40,000 and can buy additional capacity from the bank to increase the number of allowed simultaneous bids. Each game lasts for twenty minutes, fifteen minutes of game play followed by a five minute break.

In each study, each individual participant was given a personality test, Keirsey Temperament Sorter Test. All the participants were identified to be Guardians in this study. There was no individual with personality type Idealist. This is possible because of low proportion of Idealists' in general. The original hypothesis looked to determine the impact of Idealists, but as will all research one must deal with the hand dealt. The study

of four Guardians is in itself of interest and tolerably rare event, so the study looked at four Guardians. The implicit hypothesis in this study is that Guardians should all be economically efficient bidders.

It has been observed that when Guardians play against other personality type they outperform but when Guardians play against each other the profit drops significantly. This is an interesting problem, why do Guardians perform poorly against other Guardians should be the subject of further research.

The next stage is to look to the sub-groups within the Guardian personality type. The bidders with characteristic property ISTJ according to the Test, or also called Inspector, were more competitive than other Guardians. Further work is recommended to understand the behavior difference and bid pattern for sub categories of Guardians.

DEDICATION

My work is dedicated to Mentors, Family and Friends.

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NOMENCLATURE

Definitions

The following list contains terms associated with the reverse auction bidding game. These terms were defined by the previous RAB researchers at TAMU:

Reverse Auction Bidding: Reverse auction bidding is a type of auction in which the roles of buyers and sellers are reversed. In a regular auction (also known as a forward auction), buyers compete to obtain a good or service, and the price typically increases over time. In a reverse auction, sellers compete to obtain business and price decrease over time (Machado, 2009).

Reverse Auction Bid Study: A published study of at least one game in the TAMU series of studies. The studies are numbered RAB Study 1 for van Vleet (2004) work to RAB Study 25 for the Dharamshi (2014) work in April 2014. This study is a review study numbered twenty.

RAB Game (usually termed Game): A standard game session is 8 rounds of twenty minutes (15 minutes of play and 5 minutes break time)

Round: A single twenty minute period played usually with four players, fifteen minutes is the bid period and five minutes for rest and to allow the computer system to model the actual work week

Game Theory: A formal analysis of conflict and cooperation among intelligent and rational decision makers (van Vleet, 2004)

Bidders Personality: “The dictionary defines personality in several ways. One definition emphasizes the public, social stimulus, or behavioral characteristics of a person that are visible to other people and make an impression on them. Another definition stresses a person’s private, central, inner core. Included within this private core are the motives, attitudes, interests, believes, fantasies, cognitive styles and other mental processes of an individual. Some definitions of personality emphasize its “person” quality, personal existence, or identity features. Other meanings of personality are associated with specific disciplines or professions”

Responsive Bidder: A bidder whose bid satisfies all the terms and conditions of bidding, delivery requirements, detailed specifications is called a responsive bidder (Machado, 2009).

Aggressive Bidder: Aggressive are defined as bidders who attain highest overall returns (profit in our case) in the entire bidding process.

Average Bidder: Average bidders are defined as bidders who attain average distribution of returns in the entire bidding process.

Poor Bidder: Bidders who attain below average distribution of returns in the entire bidding process are termed as poor bidders.

Economically Effective Bidder: The bidder who attains highest overall returns in the form of profits from the entire bidding process (Machado, 2009).

Economically Ineffective Bidder: The bidder who attains lowest overall returns in the form of profits from the entire bidding process (Machado, 2009).

Economic Winner: An individual who generated the highest average returns.

(Panchal, 2007) coined this term to indicate a more successful player in the game. An economic winner makes no direct difference to the game for the player where the player has an objective of minimizing the average bid for the game. The player sees the average price for purchases and a distribution of prices (Guhya, 2010).

Economic Loser: An individual who generated the lowest average returns.

Panchal (2007) coined this term to indicate a less successful player in the game. An economic loser makes no direct difference to the game for the player where the player has an objective of minimizing the average bid for the game (Guhya, 2010).

Game: A series of jobs for the construction of a reinforced concrete floor slab, each game lasts approximately 8 to 10 weeks in game play time, with each round of the game modelling a week and occurring in a 20 minute period, with 15 minutes of bid time and 5 minutes of build time (Guhya, 2010).

Traditional Bidding: In this type of auction all bidders simultaneously submit bids in such a way that no bidder knows the bid of any other participant. The highest/lowest bidder is assumed to be awarded at the price submitted provided no other contracts opened on the decision process.

Bid Arrival: A record when bid activity occurs and creates a bid track on online bidding system. This record includes bidding information like price, bidder information, bid time, etc.

KTS: Keirsey Temperament Sorter is a self-assessed personality questionnaire designed to help people better understand themselves and others. It was first introduced in the book Please Understand Me. It is one of the most widely used personality assessments in the world, and its user base consists of major employers including Bank of America, Allstate, the U.S. Air Force, IBM, 7-Eleven, Safeco, AT&T, and Coca-Cola.

SQL: Sequential Query Language is a special-purpose programming language designed for managing data held in a relational database management system. Originally based upon relational algebra and tuple relational calculus, SQL consists of a data definition language and a data manipulation language. The scope of SQL includes data insert, query, update and delete, schema creation and modification, and data access control. Although SQL is often described as, and to a great extent is, a declarative language (4GL), it also includes procedural elements.

Defined Variables in the Game Theory

The defined variables are:

- λ player this represents the bidder group, treated as a single entity for the purpose of game analysis
- λ_i player the i^{th} bidder in the bidding group
- v player this represents the purchaser

α game	The game played between bidders in seeking economic advantage over the remaining bidders. This game almost always disadvantages the ν player, but the ν player created the system and so is responsible for the ν player's economic losses as a result
ω game	the postulated sub-game played within the Reverse Auction Bidding game between the purchaser and the bidders. In terms of this analysis it is deemed to effectively reduce to a two player game, with competition implications
τ	bid time allowed for each round of play in the game
δ	period between bid time τ that represents the work time in the game
i	Site number, $[1 \leq i \leq 6]$
j	Bid number counter, $[1 \leq j \leq n]$, a game is not valid without at least one valid bid
n	total number of bids in the game
B_j	j^{th} winning bid, where $B_v = \sum_{j=1}^n B_j$
k	bidder number $[1, 2, 3 \dots m]$
m	maximum number of bidders, typically 3, 4, 5 or 10
M_l^k	bidder k, bid set $\{l : 0 \leq l \leq p\}$

p^k	bidder k , number of bids
B_{\max}^i	represents the maximum allowable price for each site i
B_v	is the set of all winning bids, summed to the total cost for the game
K	This variable is a fixed dollar sum, representing the v player's base price, although in this game K is a vector of costs.
Γ	This variable is a fixed dollar sum, representing the v player's maximum incremental price above K
Ξ	This variable is normally defined by the set of numbers $\{\Xi 0 < \Xi \leq 1\}$, although negative values of Ξ are permitted by the Reverse Auction Bidding system. Ξ is used to normalize the profit data. A negative Ξ_j represents a loss on direct costs to the λ_i player who makes this type of bid, and enough of these bids will lead to a bankrupt player. This type of play is discouraged as the assumption in the game is steady state economic conditions in the outside economy. Future studies may look at a failing market, but that is beyond this study.
Δ_l^k	Set of price reduction or lost profit for each bid
δ_j^i	Element of each set Δ
Type ξ	A more economically effective bidder.

Type ζ	A less economically effective bidder
Type ϕ	Bidder who is within the middle of the range
L	set of all bids for the game, this is a finite closed set, it may be the Φ , but this is improbable unless all players declined to participate. But there may be zero bids for one site during a game, but generally $\{\forall L_\xi, L_\phi, L_\zeta : L_\xi \cup L_\phi \cup L_\zeta = L\}$ Clearly $B_v \subset L$.
L_ξ	set of bids for Type ξ bidders, this is a finite closed set, it may be the \emptyset , but this would only occur if all four players had identical returns, improbable but not impossible or where $L \subseteq \emptyset$, generally $\forall L_\xi : L_\xi \subset L$. It is true that $\sum_1^{p^\zeta} L_\zeta < \sum_1^{p^\xi} L_\xi$, it is true that $\sum_1^{p^\zeta} L_\zeta < \sum_1^{p^\phi} L_\phi$, but it is false that $\sum_1^{p^\phi} L_\phi < \sum_1^{p^\xi} L_\xi$, it may be true but it is not necessary in order for these sets to define the three bidder types.
L_ϕ	set of bids for Type ϕ bidders, generally $\forall L_\phi : L_\phi \subset L$
L_ζ	set of bids for Type ζ bidders, generally $\forall L_\zeta : L_\zeta \subset L$
\emptyset	empty set

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CHAPTER I

INTRODUCTION

Introduction

This thesis is an extension of a number of Reverse Auction Bidding studies performed at Texas A&M University. This research is 24th study on Reverse Auction Bidding and is fundamentally based on previous studies. The principle study was performed by van Vleet in 2004. This thesis presents the literature review related to the current research, the study methodology, provides an outline of the results and the analysis and also provides conclusions on the research. This chapter outlines the background to the study, summarizes the purpose of the study, develops the hypothesis and outlines the limitations of the study research.

This thesis includes details of the game developed by van Vleet (2004) and thus, some of the game description, material and figures in this report is common to this study and other related studies in the past or in present research works.

Background

Auction can be defined as buying or selling of goods or services by offering them up for bid, accepting the favorable bid and then selling the product or services to the winning bidder. In this type of bid, the bid price increases and the seller is hoping to make a profit and the buyers hopes to achieve a minimum cost for this services. This type of auction is known as Forward Auction. Reverse Auction Bidding (RAB) is form

of bidding where the buyer and a set of sellers adopt slightly different roles when compared to forward auction. In RAB, the seller competes to obtain business from the buyer, during the bidding period prices will decrease if the seller bids lower than the current posted competitor's price. This system is designed to bring the cost of services or product down and as the buyer hopes, reduce the overall cost. RAB is an accepted method for purchasing in construction industry, although it is still controversial (Jap, 2002).

The purpose of this proposal is to outline the intended research work into an aspect of Reverse Auction Bidding related to the performance of two personality types. This proposal outlines the literature review, the study proposal, limitation and methodology.

If we start with a thought experiment, a buyer makes available a tender document on a RAB system. Bidder one determines the lowest price that their company can sustain as an acceptable profit level. It has been assumed for this game that the bank acts as a control on bidding values, and each company has to make an industry average profit at a level of 10%. There is no incentive for the bidder to bid low on the first bid, so the bid is at high end of what the bidder considers is an acceptable maximum price for the purchaser. If no one else bids, they are busy say, the bid succeeds and the purchaser pays a penalty. This is essence of the problem with RAB, competition can be only artificial.

The construction industry is one of the oldest industries. Construction companies claim they are finding it hard be competitive and profitable in the ever expanding market

place (Van Vleet, 2004). With an industry that claims that it is already subjected to high failure rate and marginal rate of returns, RAB may be impacting a contractor's ability to make profit. Generally in construction contracts are awarded on basis of sealed proposal where once the bid is submitted, one is not allowed to change the bid amount in any case (Van Vleet, 2004). These sealed proposals are to be delivered before the specified time and at the specified destination. The method is assumed in normal economic circumstances to drive down construction cost. Or using Construction Management at Risk where the bidder makes an upper limit offer. Reinisch (2011) showed that CM at Risk did not appear to reduce overall cost.

But now in an attempt to reduce construction cost, both private organizations and government agencies are adopting RAB, where each pre-qualified bidder is able to see what others are bidding and can change the bid. Though this process has been seen as a success in material, supplies and other commodity procurement as reported by both private corporations as well as public agencies, it is a point of research interest as to whether it has a place in large scale construction where there are a great number of variables.

It is been assumed that RAB tends to drive owner's costs down at expense of contractor's profit. It is theorized that RAB process could cause companies to operate at lower profit and potentially driving them out of business. The TAMU RAB game system is designed to operate in a steady state condition, the business are not under extreme economic pressure, that topic may be part of future study.

It is also theorized by some critics that many firms will be awarded work that is far beyond their work capability and scope. And still some think that “reverse auctions are basically unethical and don’t contribute to the long-term interest of either buyer or the seller” (Harbert 2003). In terms of unethical behavior, economists see RAB as similar to buying a car. A purchaser takes an offer from Dealer A to Dealer B in an effort to drive down Dealer B’s price. This is ethical behavior, so by analogy the same computerized system RAB is also ethical (Harford, 1995).

Airlines are now using RAB and to reduce the costs attributed to empty seats. Giles notes that grabaseat- Future, it is win-win situation: with this system the last-minute empty seats get sold and customers get a better deal than they usually get purchasing a regular fare. Delta Airlines uses RAB as a game to reduce cost incurred because of overbooking and thus pays less than \$100 rather than paying as much as \$400 to \$ 800 per oversold seat. The impact of e-Commerce is increasing as people become completely connected in the modern world and companies are communicating almost instantaneously with customers. The digital child is growing up.

Hypotheses

A bidder with the personality type Idealist (NF) will achieve greater return than a personality type Guardian (SJ).

Significance

The ultimate goal of this study is to identify the effect of personality type on bidding strategy and to check if personality type Idealist makes more profit over personality type Guardians.

In general game theory the outcomes are point of interest, although these outcomes are difficult to categorize, our study will focus on greatest return or maximum profit. This research will help to further understand the game play methods and characteristics of economically efficient bidders in Reverse Auction Bidding.

Limitations

The limitations for this study are:

- The participants of this study are selected from students in the Department of Construction Science
- None of them has any previous experience using an RAB system
- All games will be limited to four players as is normal in this RAB study
- Economic and all the other conditions that may have an adverse effect on the bidding process are assumed steady throughout the period of this study.
- A cohort of these student will be tested of personality, the tests will be used to identify an Idealist and a guardian who will be asked to play. Two other players will be selected using random selection from the group that does not include Idealists or Guardians. If twenty subject are not sufficient to identify an Idealist or Guardian another group of ten will be selected.

CHAPTER II

LITERATURE REVIEW

Introduction

RAB is a process in which a buyer of products or services requests formal bids from a qualified seller until a system control stops the auction. The control in this research game is a time period of 15 minutes for each game. Alternate periods were tried but proved to be a problem for the development of competition.

Of course, human nature is to seek the lowest price for a set of goods/services; price is almost always the key element considered while making a purchase or requesting a service. Some forms of modern bidding systems are designed to favour companies with previous experience in the field or with the purchaser. Often these systems are pushed by sellers who have an obvious vested economic interest in these matters.

In the research based web site RAB is in essence an e-Procurement method game. The first question that is asked is the reality of the game. One case study was rigged to create an artificially low bidder, or an Owner's mole in the game. As the mole noted after the game, "I was called some quite nasty things in Hindi," indicating how seriously the game is taken by the players.

Each bidder is given a login identity and password to enter the bidding game play. Each of the pre-qualified bidders are able to see what others are bidding and thus can change the bid price during the bidding period, where they can lower the bid price

against the current bid price. Using this method, the identity of each bidder is anonymous. This method is said to be opposite to forward auction where the prices go up, hence the bid price in here go down. Once no further bids are received after a certain period following the receipt and posting of the last bid, the auction is closed. A contract award is then made to the lowest bidder (Shankar, 2005). It is traditional in reverse auction construction contracts to pre-qualify bidders based on history, experience, or other related qualification factors. Prequalification overcomes the issue of not selecting the lowest price, here the lowest valid price from an acceptable bidder is accepted.

As RAB is price sensitive, pre-qualification is needed to ensure quality is to find product from an acceptable source. This system has some advantages, generally however, lowering the price for the purchasing is not one of them (Guhya,2010).

It is also assumed that personality type affects the success parameter in RAB. Studies have been conducted by Machado (2009), Guhya (2010) and Saigaonkar (2010) at TAMU to analyze how the bidders' personality impacts on the RAB. The personality test used in this research is based on the Keirsey Temperament Sorter test, from an original suggestion by Rogers (2010). The early work showed tentatively that the major personality type of Guardian achieves the highest profits in comparison to the other personality types. Piper's recent work did not show this result, his work showed the personality type Idealist performed better than three guardians. This finding may have been as a result of the limited number of idealists in the total population, so that one had not previously been tested in the game. Piper's (2013) work using professional builders

and estimators was the first game played with these types of players using the Reverse Auction Bidding System at TAMU.

Other Auction Types

This section presents a summary of other auction types and issues associated with the system including:

- Traditional Types of Auctions
 - Vickrey Auction
 - English Auctions
 - Dutch Auctions
 - Sealed First Price Auctions
 - Other Types of Auctions
 - Reverse Auction Bidding
- Reverse Auction Bidding in Construction Industry
 - Posited Savings for RAB
 - Procured Items
 - Legal Issues
 - Buyer to Seller Relationship
 - Reverse Auction Bidding Myths and Reality
 - Influence of Personality Types to Reverse Auction Bidding Outcome
- Mathematical Theory of the Reverse Auction Bidding
- Bid Arrival Timing and Other Game Issues

- Summary

Traditional Types of Auctions

An auction is that one can procure goods and services through the use of a bidding mechanism. Traditional auctions are based on long-standing theoretical foundations and tested empirical work (Parente, 2008) . There are different kinds of traditional auctions and Klemperer (1999) classified four main types of auctions. These four auctions are English auctions, Dutch auctions, sealed first price auctions and the Vickrey auctions. There are also other types of auctions, including the Japanese auctions, the Take-it-or-leave-it auctions, and the Candle auctions, to list some of the variants.

English Auctions. English auction, also known as forward auctions or ascending auction is the most commonly used form of auction. It is suitable for limited supplied goods or unique sold items (S. Wamuziri, 2009). In English auctions, the bidding process was started with the lowest acceptable price for seller, usually the reserve price. Each bid after that point must exceed this price. As a result, a seller could keep the item from selling for less than this reserve price, where it has been set at the beginning of the auction. Bidders then begin bidding over the items against each other by placing higher price than the last bid. The auction terminates when no more bidders are willing to offer a higher price. Moreover, the item sells at the highest bid. A seller will hold the items, if the final bid price does not exceed the reserve price. The notable characteristic of English auction is that each bidder knows the level of the current best bid during the whole auction process (McAfee & McMillan, 1987).

This type of auction is used to sell antiques or artworks. The point is to maximize returns by allowing the market to establish the price points (Hartford, 2005). As you would expect for these types of auctions for topline artwork the market has developed to a few centralized locations in England and New York.

Dutch Auctions. Dutch auction, also called multiple items auctions or open descending price auction (Krishna, 2009), is named for the Dutch tulip auctions. It is a converse type of auction when compared to the English auction. The seller initially calls a very high price. Seller will constantly lower the price through each round of bid until a bidder is finally willing to accept this price. The Dutch auction relates the price paid to the time of the auction. Namely, the longer the auction goes on, the lower the price.

In a Dutch auction, rational bidders always have their own clearly acceptable valuation of the item for sale. The auction begins with a price, which is inevitably over this valuation, while the bidder keeps waiting. Once the successively lowered sale price comes down and reaches this amount, a buyer may accept this offer but obtain a zero profit. Waiting longer to bid a lower price will increase the bidder's profit. However, this behavior provides the economic risk that the bidder may end up losing the item to another bidder (S. Wamuziri, 2009).

So Dutch auctions force bidders to think about their own valuation of the item before the auction and act decisively while bidding. This type of auctions is often used for perishable items (McAfee & McMillan, 1987) like flowers in the Netherlands, fish in Israel, tobacco in Canada, and used furniture. These items are used locally, in contrast to

the art auctions, where the product may end up at any location in the world that a major art collector chooses to live.

Sealed First Price Auctions. Sealed first price auction is a first price sealed bid auction (FPSB). Different from English auction, all bidders just simultaneously submit only one bid (Krishna, 2009). Like the English auction, the item goes to the highest bidder.

Sometimes, a seller will choose the winner randomly from those who name the same highest bid, if there is a tie. The fundamental rule of sealed first price auction is that all bidders could not know the bid information of other competitors before the end of the auction and also couldn't adjust their own bids according to other's bids (McAfee & McMillan, 1987).

In sealed first price auction, the bidder gets three options. They are:

- to bid his/her full valuation
- to bid a shaded value of the full valuation
- to bid considerably under the valuation (S. Wamuziri, 2009).

Options 3 may lead the bidder to losing the bid to their competitors, while option 1 could gain the bidder no profit if their bid was successful. As a result, rational bidding strategy for sealed first price auction should be bidding with a shaded value of the full valuation. With this approach, the bidder could make a profit and win the bid at the same time. The bidder gains more profit with higher shaded value held. Too much shaded value may increase the risk of losing the bid.

So, this kind of auction forces bidders to guess the valuation of others' and bid a little more than this amount (S. Wamuziri & Abu-Shaaban, 2005). Some UK

construction procurement uses this type of auctions. UK construction is often based on the work by the Quantity Surveyor who provides an estimate of the construction costs to the purchaser (RICS, 2000); this system has a number of economic advantages for the purchaser in having:

- a pre-bid estimate from an expert estimator
- a consistent set of quantity take offs guaranteed by an independent expert
- a standard for the quantity methods that is agreed across the industry
- a document that has been tested in the courts

Vickrey Auction. Sealed second price auction is similar to sealed first price auction, where all bid will be sealed and revealed at the same time. What makes them different is that the winner of this kind of auction only needs to pay the second highest price bid other than the highest one. It is also called Vickrey auction to commemorate the economist who first put forward that this type of action as it pushes each bidders to bid their true valuations (S. Wamuziri, 2009). Overall, the best strategy of sealed second price auction is to bid the true value, which is identical to English auction. However, they have different information transparency (S. Wamuziri, 2009), since sealed second price auction needs information transparency.

In addition, each bidder is in a passive condition. As a result, sealed second price auction is seldom used in practice. A sealed second price auction is a very good tool to model bidder's behavior, since bidder needs to bid their true value. Vijay (Krishna, 2009) pointed out that sealed second price auction is in some ways similar to proxy bidding system, which is used by Internet auction site like eBay. In eBay, a bidder who

bided the highest is awarded the bid by actually paying the current highest bid plus the current bidding increment (Krishna, 2009).

Other Types of Auctions. Besides those four types of auction mentioned above, there are still some other types, like Japanese auction, Take-it-or-leave-it auction and Candle auction. In a Japanese auction, the price rises up through each round of bid. Each bidder shows if they are willing to stay at the current price level for each round. Once a bidder quits, the bidder will not reenter the auction. In Take-it-or-leave-it auction, the seller announces the price of each project, and bidder can choose accept (“take”), which leads the end of auction, or reject (“leave”) the bid, after which seller goes to the next. The clear advantage of this type of auction is that protect the private valuation information (S. Wamuziri, 2009). In Candle auction, the bid is awarded to the last bid price before a candle burns out (S. Wamuziri & Abu-Shaaban, 2005). This is similar to the RAB where a timer runs out.

Reverse Auction Bidding. This is a relatively new type of procurement method, which has the roles of the bidder and seller completely different from forward auction. It is also regarded as an internet-based system. This new type of auction that was known in the mid-1990s as Business-to-Business (B2B) online Reverse Auction (Schoenherr & Mabert, 2007). The establishment of Web auctions as a tool to facilitate exchanges between buyers and suppliers is emerging as a new business paradigm. After this experiment a part of the Naval Supply Systems Command, in May 2000, tried Reverse Auction Bidding (Mabert & Skeels, 2002).

At the same time, many Fortune 1000 companies began tasting the benefits of this new method of procurement (Emiliani & Stec, 2001). Web auctions of products like service or commodities are using sophisticated advertisement techniques to display the product being offered for sale. United Airline has started an online auction system for first class upgrade, this system has two similarities with Reverse Auction Bidding, the first one is that a group of bidders make offers for a special seat, the other one is the United Airline will select the best offer to maximize their returns, which is also the market driven for Reverse Auction Bidding. The overall expectation from this published research is that the overall average price for bids obtained using the Reverse Auction Bidding Process would be lower than a hard bid system.

This statement has not been shown to be correct at this time, nor is ever likely to be provable.

Reverse Auction Bidding in Construction Industry

In construction, the use of Reverse Auction Bidding is increasing. At a scheduled time, the owners open a bidding site with a “game” and bidders who are interested in the project submit their price to the web-based system. Then the web-based system posts the prices on the site for all bidders to compete. Contractors can lower the price to win the bid in a certain period of time. Compared to traditional sealed bidding, in which all bids from other bidders are kept confidentially, Reverse auction bidding provides opportunities for subsequent bidding after prices are open (Shankar, 2005)

Some corporations use the Reverse Auction Bidding method to buy their construction materials. For instance, the Minnesota Department of Administration

procure the construction products with the RAB method. In addition to the purchase of commodities, in a recent case, Pennsylvania's Department of General Services also use the RAB technique procure construction services.

Several private companies, such as Target have used Reverse Auction Bidding systems (Shankar, 2005; Yuan, 2013).

Lowest Price Guarantee

The Reverse Auction Bidding process does not always produce the lowest cost. Consider the thought experiment, Bidder 1 is prepared to accept \$50,000 for his piece of a contract but Bidder 1 starts the bidding at \$80,000 because the bidder can lower this price later in the process. Other bidders submit their numbers, and Contractor 1 submits a lower bid at \$60,000. None of the other bidders enter a number before time expires, and the \$60,000 bid wins. The owner now pays \$10,000 more than the bidder's base bid.

Reverse auctions also create an environment in which "bid discipline" is critical yet difficult to maintain because of multiple bidding in a short time, which does not allow adequate time for reassessment (Gennett, 2005). When using sealed bidding, you only have one chance of being awarded a project. For this reason, when price is the only concern AGC believes that sealed bidding, is better for the owner than reverse auctioning. Reverse Auction Bidding does not focus on one of the components to successful construction, which is communication. The negotiation processes helps to obtain the best value for the owner by taking in considerations such as quality, system performance, time to complete and overall value. In fact, current studies of Reverse

Auctions between buyers and suppliers have found that Reverse Auctions often have a deleterious effect on the relationship between buyer and seller (Gennett, 2005).

Posited Savings for RAB. One study indicated that a properly executed reverse auction has the potential to save an additional 8 percent to 20 percent cost for an organization below its current price (Guillemaud, Farris, & Hooper, 2002). The Minnesota Department of Administration benefited from the use of RAB, which enable the Minnesota Department of Administration drop the price of the aluminum it purchased from \$1.555 per pound \$1.029 in 45 minutes. The state achieved a saving of \$150,000 for taxpayers about over the course of five years. As summarized by the state, “A reverse auction gets to the absolute lowest price a vendor will offer, as opposed to a bid price [under the traditional sealed bid approach] that might not be the bottom line price” (Shankar, 2005)

RAB has its own flaws or challenges to not only sellers but also buyers, everything has two sides. Strategic relationships and partnership between buyers and sellers might be impaired. “Because of excessively focusing on price, the online reverse auction has caused a move away from the close partnerships that were once successfully working for both buyers and sellers. An empirical study concluded that high emphasis on two main benefits of reverse auctions, purchase price reduction and time savings (procurement process efficiency), negatively impact the buyer-seller cooperation and sellers’ strategic relationships” (Percy & Larry, 2007). In order to win the bid, a seller has to lower its margin to a bare minimum. With such a low margin, there is no room for any adjusting and adapting to unforeseen situations. It can jeopardize long term buyer-

supplier relationships; reduce the suppliers' trust and cooperation. Ultimately, it can even lead to the erosion of the supply base and result in less competition and higher prices.

Figure 1 clearly shows the problems with these claims. Results from earlier studies showed that the bidding set L has a distinct non-normal distribution when the data is normalized.

A good game strategy can provide some players with returns higher than the average. Anecdotal evidence on Reverse Auction bidding shows that this happens in real systems. In terms of game theory, an auction can be considered a game between players. One player, ν , has a good for sale in a traditional auction and a good to purchase in a reverse auction.

The other player, λ , is typically a group that is bidding to purchase the item in a traditional auction or sell the item in a reverse auction. The λ player derives from the concepts put forward by Church (1941). The λ player sees a different statistical distribution set for each player in the λ group, but the ν merely observes one statistical distribution set. These statistical distribution differences form the basic element to this research work, as the point is to develop a machine bidder that outbids all human bidders, but is humanlike (Abelson, Sussman, & Sussman, 1987; Winston & Horn, 1989).

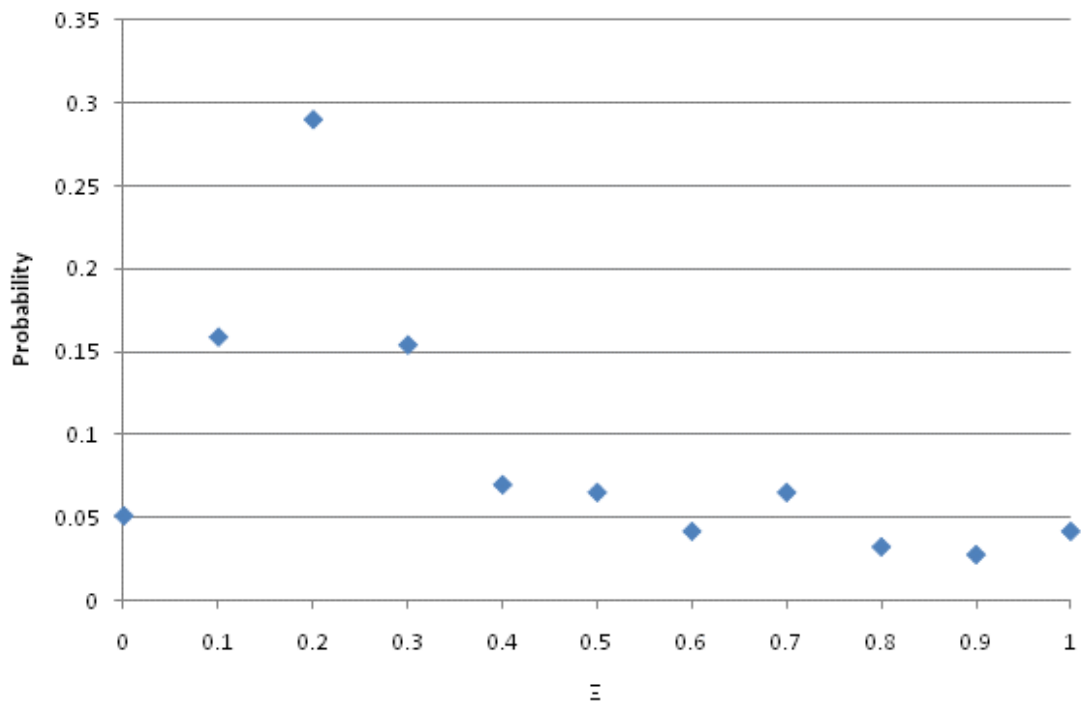


Figure 1. Normalized profit data for two earlier studies, after Saigaonkar (2010)

Procured Items. The discussion, which questioned the feasibility of Reverse Auction Bidding of all kinds of products, has never stopped. Some researchers (Mabert & Skeels, 2002) studied some cases and concluded that Reverse Auction Bidding could not be suitable for every purchasing contract. Products, like strategic items and direct inputs, are not that accessible to Reverse Auction Bidding due to their long-term contract requirement or oligopoly among sellers, (Schoenherr & Mabert, 2007). The suitable ones included complex and highly-engineered items (Wagner & Schwab, 2004) or standard projects. Jap (2002) put forward that the only suitable products should be commoditized products.

Schoenherr & Mabert (2007) explore this myths that Reverse Auction Bidding is commodities-products-only auction. They suggested having Reverse Auction Bidding for non-commodities products by refining the RFQ order, conducting market research and analysis, defining detailed and specific attributes of projects, and using specialized third-party consultant.

Legal Issues. As a new modern method of procurement, Reverse Auction Bidding attracted more and more attention from manufacturing and service sector business and government agencies. Its popularity also raised the concern of its legal and contractual issues. Research dealing with legal issue indicated that there was some unfair trade practice (Engel & Emiliani, 2007) during Reverse Auction Bidding. The unfairness came from the unequal positions of buyer and sellers.

Sellers were facing sort of coercion in Reverse Auction Bidding. Horlen, Eldin, & Ajinkya (2005) analyzed the future legal challenges of Reverse Auction Bidding in terms of some legal grounds, like Federal Trade Commission, Anti-Dumping Act of 1916, Robinson-Patman Act, Clayton Antitrust Act and Business Method Patents.

Reverse auction was banned by the Federal Acquisition Regulation (48 CFR 245.610 and 48 CFR 15.610), because some flaws in legal performance (Merson, 2000), however, the prohibition was later removed. Though legal challenges existed in Reverse Auction Bidding awarded contract, Reverse Auction Bidding is still appealing to public buyer, like large international companies and government. The state of Texas, Pennsylvania, Kansas, New York State, Missouri, Minnesota, and Wisconsin (Horlen et al., 2005) had approved the legislation to allow Reverse Auction Bidding.

Economically the system is transparent and one could argue fair for all parties, provided that a coercive relationship does not exist or the game is not rigged, (Giampietro & Emiliani, 2007).

Buyer to Seller Relationship. Since price became the relatively decisive element in Reverse Auction Bidding process, the expected side effect is the negative impact Reverse Auction Bidding might bring to the buyer-supplier relationship. It is possible that buyer may omit the non-price elements like reputation, quality and previous partnership etc. This may result in deterioration of previous seller-buyer partnership. People question whether Reverse Auction Bidding can be used in procurement, which requires long-term seller-buyer relationship. Reversed auction was recognized to bring new business to new sellers who could offer lower price, while making current seller annoyed at losing the hard-won long-term business (Emiliani & Stec, 2005). Due to its price oriented characteristic, Reverse Auction Bidding could lead to profit margin erosion (Emiliani & Stec, 2004) and coercion to sellers. In construction industry, seller-buyer partnership could be impaired when contractors, who won the contract with lowest price in Reverse Auction Bidding, would charge higher prices for change orders and extra work if client ordered, in order to keep their profit margin (S Wamuziri, 2009).

While some researchers tried to refute by putting forward the idea that Reverse Auction Bidding could potentially benefit both sellers and buyers at the same time. Some researchers suggested that buyers, who need collaborative and long-term relationship sellers, can use Reverse Auction Bidding as a process improvement tools to check market price instead using it as a price weapon (Smart & Harrison, 2003). Also,

the buyer-seller relationship can be kept fair to all by prequalifying bidders with non-price elements, detailing RFQ, providing education, training and assistance to bidders during Reverse Auction Bidding process (Schoenherr & Mabert, 2007).

An important economic observation is when all things are equal the prices should be the determining factor (Hartford, 2005) for projects funded by shared equity. Reinisch (2011) showed the problems with alternative bidding systems.

Reverse Auction Bidding Myths and Reality

Schoenherr and Mabert (2007) studied 30 case studies for companies that had participated in RAB systems, which enable them investigate the most common myths related with Reverse Auction Bidding. They discussed myths for Reverse Auction Bidding:

- Reverse Auctions are only about the price;
- Reverse Auctions are only suitable for commodities;
- Reverse Auctions damage the buyer-supplier relationship;
- Savings in Reverse Auctions will decrease;
- Reverse Auctions are passing fad.

Figure 2 shows the current myths about reverse auction in the industry. Schoenherr and Mabert (2007) studied the reality versus the myths based on their study of 30 companies.

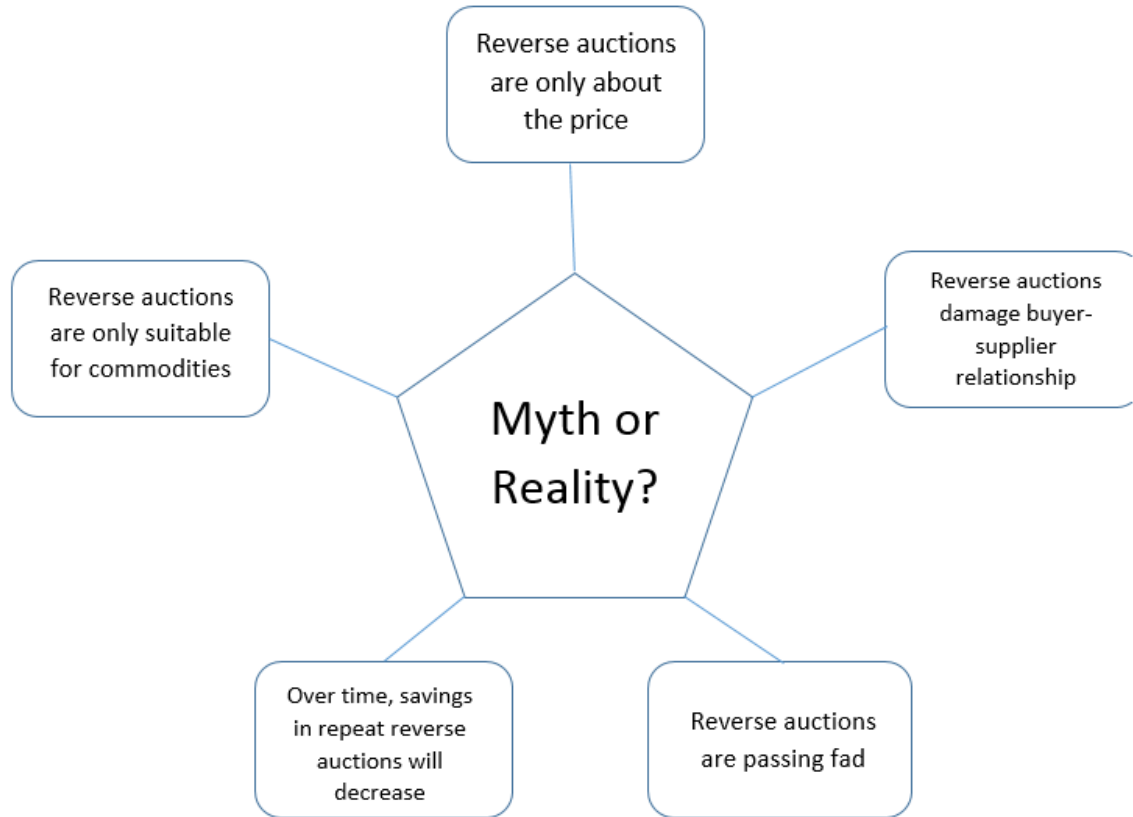


Figure 2. Common RAB myths after Schoenherr and Mabert (2007)

The findings are:

- While a lower price is one objective in reverse auctions, it is often not the most important one, and can be easily complemented with non-price attributes
- While commodities are usually easier candidates for reverse auctions, non-commodity items can also be put up for bid successfully
- While reverse auctions can hurt buyer–supplier relationships, there are many ways to prevent that from happening

- While first-time bidding events likely result in higher savings, continued cost advantages are possible
- While reverse auctions will not be used as much as in the past, they are here for the long-run

Influence of Personality Types to Reverse Auction Bidding Outcome

Students from Texas A&M University have conducted studies on RAB for the last decade. The research was commenced by van Vleet (2004), the theoretical basis of the study is the simulated bidding process which reflected the project of supply of slabs in Houston. In the following year, Shankar (2005) tested the methods from van Vleet's study and showed that the results could be replicated. Rogers (2010) suggested that personality may have an impact on returns.

Further studies have been conducted by Machado (2009) and Saigaonkar (2010) at TAMU to analyze the bidders' personality impacts on the results. The work is based on the Keirsey Temperament Sorter test. Keirsey Temperament Sorter is a self-assessed personality questionnaire designed to help people better understand themselves and others. The test and scoring method are presented in Appendix A and B respectively.

The Keirsey Temperament Sorter test has seventy-one questions, and identifies sixteen types of personalities that fit into four groups SJ - The Guardians, SP - The Artisans, NT – The Rationals, and NF - The Idealists.

Table 1 shows the Keirsey Temperament Sorter Test categories. In addition, summary of individual components of the different are provided in Table 2.

Table 1

Keirsey Temperament Sorter matrix

	Temperament	Role	Role Variant
Introspective (N)	Idealist (NF)	Mentor (NFJ)	Teacher (ENFJ): <i>Educating</i>
		<i>Developing</i>	Counselor (INFJ): <i>Guiding</i>
	<i>Diplomatic</i>	Advocate (NFP)	Champion (ENFP): <i>Motivating</i>
		<i>Mediating</i>	Healer (INFP): <i>Conciliating</i>
	Rational (NT)	Coordinator (NTJ)	Field marshal (ENTJ): <i>Mobilizing</i>
		<i>Arranging</i>	Mastermind (INTJ): <i>Entailing</i>
		<i>Strategic</i>	Engineer (NTP)
			Inventor (ENTP): <i>Devising</i>
		<i>Constructing</i>	Architect (INTP): <i>Designing</i>
		Administrator (STJ)	Supervisor (ESTJ): <i>Enforcing</i>
Observant (S)	Guardian (SJ)	<i>Regulating</i>	Inspector (ISTJ): <i>Certifying</i>
		Conservator (SFJ)	Provider (ESFJ): <i>Supplying</i>
	<i>Logistical</i>	<i>Supporting</i>	Protector (ISFJ): <i>Securing</i>
		Operator (STP)	Promoter (ESTP): <i>Persuading</i>
	Artisan (SP)	<i>Expediting</i>	Crafter (ISTP): <i>Instrumenting</i>
		Entertainer (SFP)	Performer (ESFP): <i>Demonstrating</i>
	<i>Tactical</i>	<i>Improvising</i>	Composer (ISFP): <i>Synthesizing</i>

Table 2

Summary of the individual components of the different personality types

#	Name	Meaning
E	Extraversion	Feel motivated by interaction with people. Tend to enjoy a wide circle of acquaintances, and <i>gain</i> energy in social situations
N	Intuition	More abstract than concrete. Focus attention on the big picture rather than the details, and on future possibilities
F	Feeling	Value personal considerations above objective criteria. In making decisions, often give more weight to social implications than to logic
J	Judgment	Plan activities and make decisions early. Derive a sense of control through predictability
I	Introversion	Quiet and reserved. Generally prefer interacting with a few close friends rather than a wide circle of acquaintances, and <i>expend</i> energy in social situations
P	Perception	Withhold judgment and delay important decisions, preferring to "keep their options open" should circumstances change
T	Thinking	Value objective criteria above personal preference. When making decisions, give more weight to logic than to social considerations
S	Sensing	More concrete than abstract. Focus attention on the details rather than the big picture, and on immediate realities rather than future

This research has shown tentatively that when there are all major personality type of Guardian bidding against each other the sub category Guardian: Inspector (ISTJ) gives best performance in comparison to the other Guardians. This results are been identified for the first Thus, this requires further studies and demonstrates the complexity of the personality problems. A significant amount of work has been completed on personality impact at TAMU, clearly personality is one factor that affects performance.

Mathematical Theory of the Reverse Auction Bidding

The earliest research was interested in the ethical issues associated with Reverse Auction bidding systems. The main conclusion is that a purchaser is free to use a RAB system to purchase good, there are however several issues:

- If only a single bid is submitted it is not likely to be at the lowest cost
- Single bids occur frequently even in competitive games
- humans make mistakes and miss things

This mathematical theory has been used to review a number of case studies completed at TAMU, both with graduate students and now a set of four professional estimators (Piper, 2013). (Guhya, 2010) defined the bidders as Type ξ to represent a more economically effective bidder and as Type ζ to represent a less economically effective. Nichols (2010) defined Type ϕ Bidder as bidders who is within the middle of the range for complete the set L . Type ϕ have not yet been formally and statistically observed (Nichols, 2010).

(Guhya, 2010) also discussed the Mathematical Theory of the Reverse Auction Bidding. Consider a Reverse Auction Bidding game where the ν player is willing to accept bids of the type shown in equation (1):

$$B_j = K + \Xi_j \Gamma, \quad (1)$$

Γ represents the upper limit the ν player is prepared to pay in the game above the nominal minimum bid amount K . A negative Ξ represents a loss on direct costs to the λ_i player who makes this type of bid, and enough of these bids will lead to a bankrupt player. The concept of Γ can be attributed to Professor Feigenbaum (Guhya, 2010), who considered there had to be an upper limit everyone was prepared to pay for a service or good.

The bidding period for each game lasts for a set time, τ , in this case it is 15 minutes. The total cost for ν player is shown in equation (2):

$$B_v = \sum_{j=1}^n B_j, \quad (2)$$

This total cost is based on the accepted lowest bid for each job, where a valid bid was submitted by the λ player. Each λ_i player then has a unique set of bids and a unique set of jobs, with a total return to the λ_i player defined by a simple summation.

The results of this statistical analysis using equation (1) and (2).

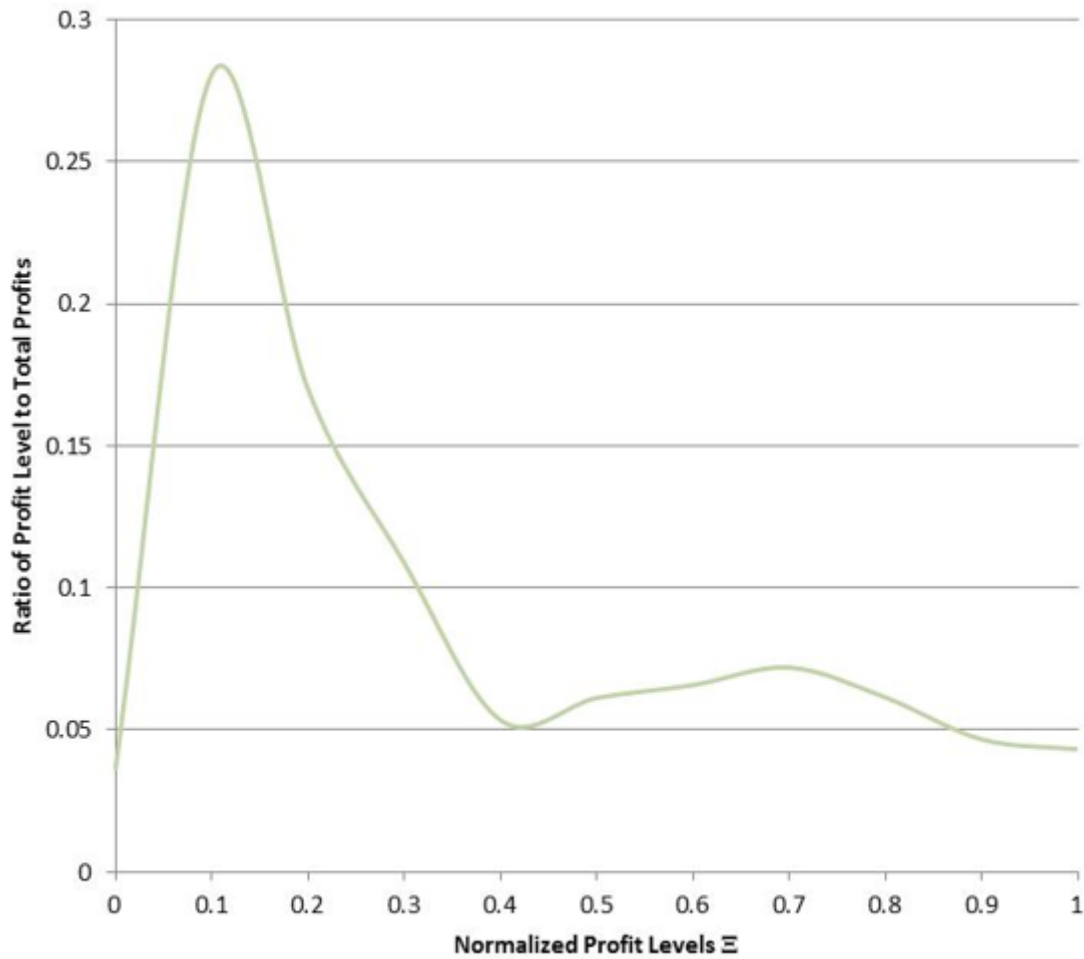


Figure 3. Normalized profit levels for the four player game

There are clearly two elements to the distribution, which has been consistent across game play from the earliest studies.

Bid Arrivals

A research group has studied the arrival time of eBay bidding (Shmueli, Russo, & Jank, 2007). They stated that the arrival time of eBay bidding will fit the BARISTA model. The BARISTA (Bid ARrivals In STages) is a three-stage nonhomogeneous Poisson process. The first stage is “espresso stage” (short and intense), in which the

bidding start. The second stage is called *macchiato stage*” (stained), which is during the mid-auction period with increasing intensity. The third stage is last moment of bidding, called “*ristretto stage*” (extra intense). In this stage, there are extremely intensive activities. This study gives instructions about the best time to bid. A Poisson process is a special type of Markov process that happens in a fixed consecutive time period (Boxma & Yechiali, 2007). As a continuous-time process, it is a mathematical model of a completely random series of events (Cox & Lewis, 1966).

Yuan (2013) analyzed 6674 reverse auction bidding bid arrival times for nine previous TAMU reverse auction bidding case studies. Table 3 shows the individual Reverse Auction bidding games used by Yuan.

A Poisson process counts the numbers of occurring events along the timeline and the time of the occurred events in a certain time interval. According to its characteristics, it is also a type of point process of the real half line. Yuan found that the results show that the Poisson process model for the arrival times fits the non-homogeneous Poisson process (NHPP) model. The results from her study have the similar heterogeneity in RAB bidding dynamics to the situations of eBay online auction that were studied by others (Russo, Shyamalkumar, Shmueli, & Jank, 2004; Shmueli, Russo, & Jank, 2004; Shmueli et al., 2007).

Table 3

Reverse Auction games studied by Yuan

Experiment Date	Researcher ID	No. of Contractors	No. of Section	No. of Projects	No. of Bids
5/4/2004	1	5	8	86	773
5/29/2006	2	4	25	118	192
6/4/2006	3	9	13	156	1077
11/5/2007	4	4	5	43	346
4/6/2010	5	5	8	54	804
4/3/2010	6	37	10	179	776
6/8/2010	7	4	10	97	865
6/10/2010	8	4	9	92	759
6/11/2010	9	4	9	91	1082
TOTAL	9	76	97	916	6674

Figure 4 shows a plot of the bid arrival times for the ninth case study, completed in November 2010. The data shows the bids pack into the higher end of the bidding time of 900 seconds, with most bids in the period 700 to 900 seconds.

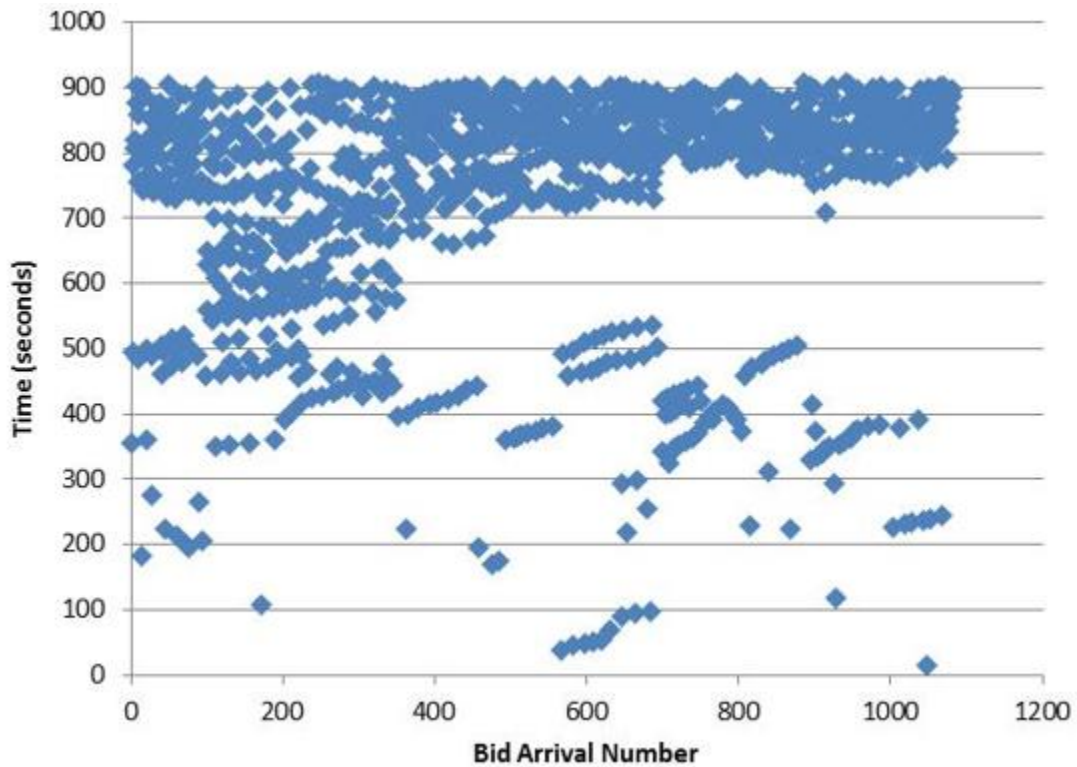


Figure 4. Bid arrival time data for case study nine

Yuan divided the 900 seconds of game play into 180 intervals of five seconds each. She counted the arrival times for each 5 second interval for the complete data set. The results are plotted in Figure 5 . The process has a theoretical upper limit of infinity, but one is constrained by the speed of human typing. Yuan in a simple study showed that a cutoff number of bids per second existed and determined this value. She showed that the upper limit of 140 matches the value reasonably.

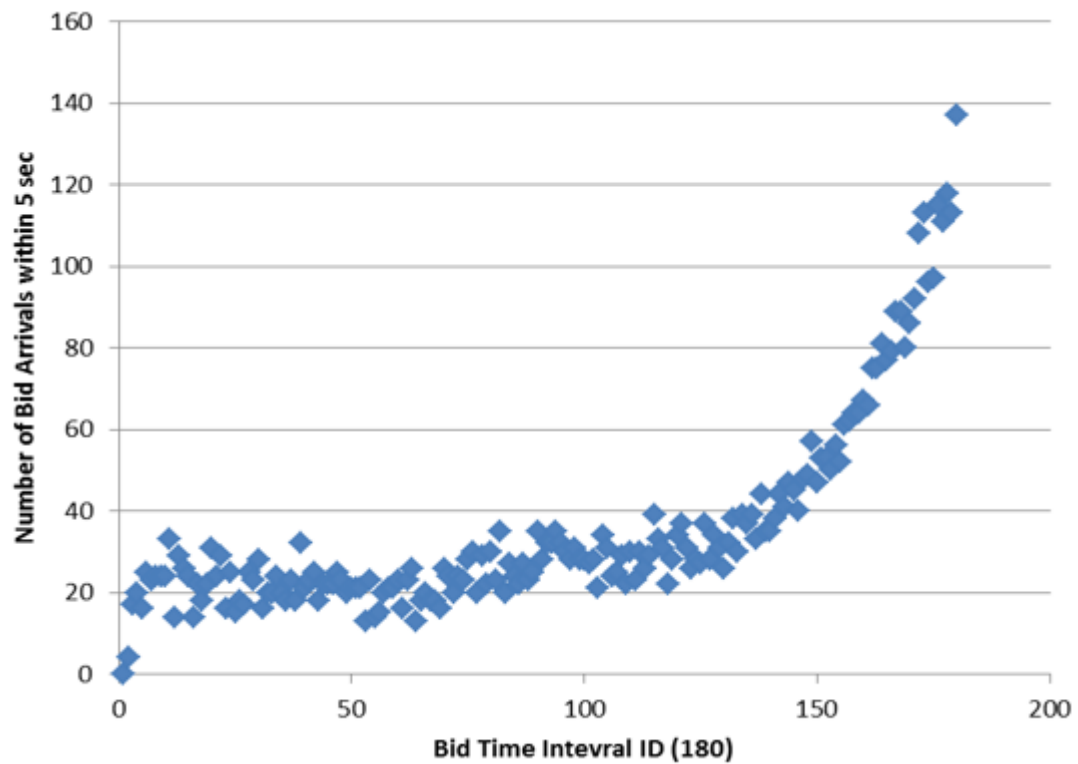


Figure 5. Bid arrivals for complete set

The author concluded from the analysis that reverse auction bidding bid arrival times follows a Poisson process, as for the eBay data (Shmueli et al., 2007).

One of the main issues over the last decade, relates to the issue of timing. The game is played on the internet, the clock time on the various devices may be different and most likely are, causing issues on determining “finish time” for each game. This is not a trivial issue, and one that should be of concern to all involved in such games.

The Reverse Auction Process in the Construction Industry

The construction industry is diverse and is equipped with unique traits. Every projects has different characteristics like: cost, time, site condition, design, and safety requirements among other variables. Therefore, are construction services a commodity and should they be subject to reverse auctions? It is this very question that has prompted strong debates between different participants in construction industry. The owners, contractors and construction industry organizations are concerned about it. The owners of construction services like the idea; conversely, numerous contractors and industry leaders feel it would be a disaster for the industry and the public at large (National Electrical Contractors Association, 2002). The critical element considered by some is that it is bid shopping, under another title.

The wide presence of the Internet has made it possible for computer systems to infiltrate every industry conceivable; making it a popular e-commerce tool in the construction industry. Since the time is a most important trend today is speeding up processes, the emphasis has been applied to cutting time on the bidding procedure while at the same time increasing competition among contractors to achieve the best profit.

From the contractor's point of view, most of the Reverse Auction Bidding proponent's initial savings are only short-term and the Reverse Auction Bidding method could actually cost owners and taxpayers more than the traditional sealed bidding process (Thompson & Knoll, 2002). As mentioned earlier, most respectable contractors equate Reverse Auction Bidding as electronic bid shopping and consider it will cause problems for the owner on long run.

It must be pointed out that Reverse Auction Bidding is a method that is used within the construction system to move a construction project from a conceptual phase to a finished product as envisioned by the original concept. The construction system flows from the point of project inception through planning, design, construction activities (prequalification, bidding, selection, contract formation, contract execution, contract administration, approvals, substantial completion, and completion and punch list). The system also includes manufacturers, suppliers and distributors of any required material.

To depict the success/failure of a method introduced into a system, clear understanding and full communication of the system functions with the method is essential. This includes the duties of the participants, both ethical and contractual, at each correlated element of the system. Any changes in the system may influence the cost and relational dependencies, and may result in ethical and/or legal problems. Therefore, to state that a change in the competitive bidding method within the construction system is ethical, fair or beneficial to the parties, a complete review of the construction system and the impact analysis of the modification are required, there is limited evidence that this type of study has been completed at this stage.

Led by federal and state governments, online bidding has gained a substantial foothold in the construction world. Arizona and Colorado enacted statutes expressly permitting state agencies to invite construction contract bids through the Internet (Berning & Flanagan, 2003). The most obvious beneficiaries of online bidding have been owners, which seek:

- (1) Secure information exchange with bidders;

- (2) Elimination of errors in bidding through system checks that eradicate bids with missing or erroneous data;
- (3) Receipt of bids in a single consistent format;
- (4) Cost Reduction in preparing and distributing bid proposals;
- (5) Increase in number of potential bidders; and
- (6) Automatic enforcement of bid submission cut-off time.

Some contractors have said that “online bidding comes as a relief,” noting that the technology, by making bidding possible from their own offices, saves them from having to pack up teams and office resources to travel to a bidding site. This could trim bid prices because online bidding spares contractors from a potentially long drive, hotel bills and the price of hauling computer equipment (Berning & Flanagan, 2003)

Summary

As an innovative procurement method, the application of Reverse Auction Bidding is growing. This literature review introduces existing procurement methods and their characteristics. Previous researchers mainly studied external effects of RAB, such as potential savings, the applicable industry, related legal issues and effects for the relation between buyers and seller. Further studies discussed the advantages of Reverse Auction Bidding, which mainly discusses the cost savings; while others imply that Reverse Auction Bidding has its flaws, like RAB hurt the long-term seller-buyer relationship.

The published article studying RAB dynamics (bidding strategies and bidder's performance) is rare, while some researchers studied the eBay auction performance.

Because the eBay online auction and the Reverse Auction Bidding have significant similarities in bidding process, this literature review referred some studies on eBay online auction. Russo (2010) has studied the arrival time of eBay bidding. She stated that the arrival time of eBay bidding will fit the BARISTA model as explained before. This study suggests the best time to bid. Yuan (2013) analyzed the bidding data of Reverse Auction Bidding from previous 9 experiments from TAMU, and the results have the similar heterogeneity in RAB bidding dynamics to the situations of eBay online auction that were studied by other Russo (2010). van Vleet (2004) started the study of Reverse Auction Bidding at Texas A&M University. This research continues today with twenty-four studies completed to date. In our research RAB is been simulated using small, simple and repetitive projects of house slabs in Houston.

Not all of the studies are suitable for use in this study, because of constraints introduced by the research question of interest to a particular study, such as owner's interference. Nine studies had data suited to this study.

Studies have been conducted by Machado (2009), Guhya (2010) and Saigaonkar (2010) at TAMU to analyze the bidders' personality impacts on the RAB returns. The studies are based on the Keirsey Temperament Sorter test. There have been studies in the areas of game theory, tacit collusion among bidders, the significance of personality, the RAB game for the role variants of guardians in different types of industrial and some specific cases studies and thus we study the impact of personality type in this research as our area of interest.

CHAPTER III

METHODOLOGY

Introduction

This chapter outlines the methodology used for the Reverse Auction Bidding game site and the specific features applicable to this research study. The chapter contains a presentation on the game description, data structure and data analysis methods.

Game Description

van Vleet (2004) was interested in the ethical aspects of Reverse Auction bidding. He developed a simple game to study aspects of RAB (Kim, 2004). The simplicity introduced by van Vleet has allowed for significant exploration of personality, bid timing and now bid differentials. In the real world, prior to a RAB round, all sellers might have gone through a prequalification selection stage, so that final bid selection is based solely on submitted price. The assumption in this study is that only those who are prequalified can be involved in RAB bidding. During the auction process, prequalified sellers can bid multiple times anonymously. The TAMU web based system uses anonymous login names for each bidder to ensure a fair system, but participant selection is from students who have some construction industry experience.

Guhya (2010) in his review of the first case study outlined the RAB game as played at TAMU as an algorithm. The algorithm is shown in Figure 6. All the data is stored in the SQL dataset first and transferred in Microsoft EXCEL for analysis.

Recently the site has been redeveloped as an ASP.NET MVC 4 site to provide a modern interface to the Microsoft SQL Server database (Paz, 2013).

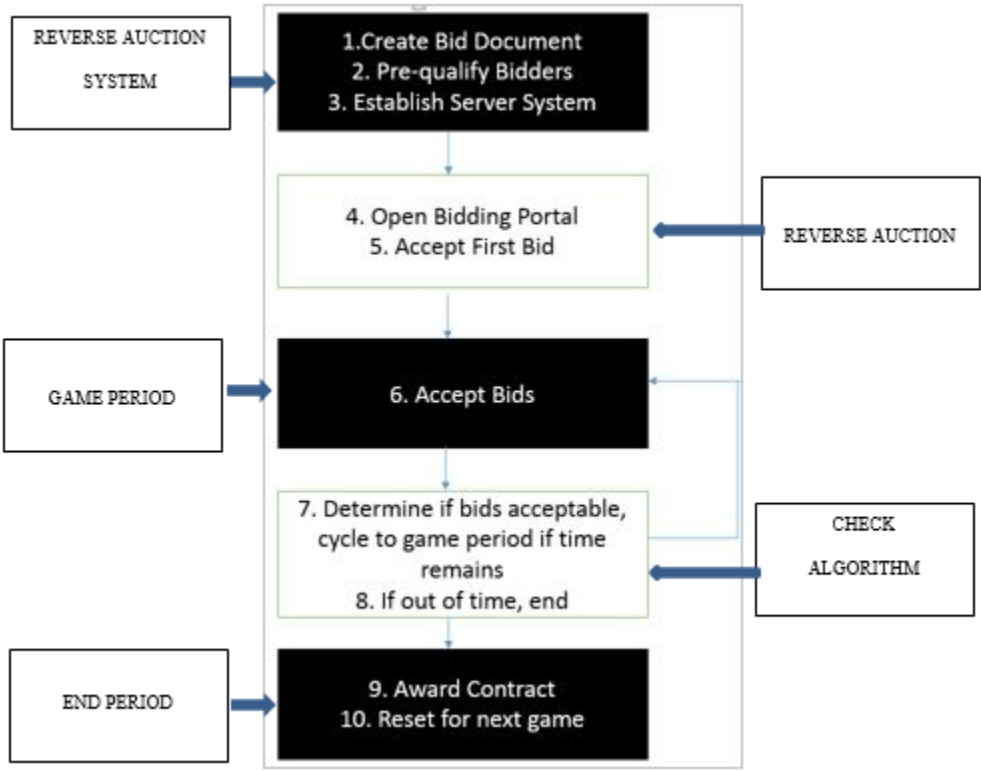


Figure 6. Reverse Auction Bidding general algorithm after Guhya (2010)

The idea is to develop some differences in the construction costs so that a single player could not follow a simple pattern to play the game. This system has been maintained in all games.

Van Vleet selected six sites in Houston for the game play. Figure 7 shows a map of the six sites used in all games since 2004. He assumed that all costs are based on the distance from Sugarland as the contractors would be near the purchaser. This is a

reasonable assumption for this game study, providing some differentiation in costs for each site.

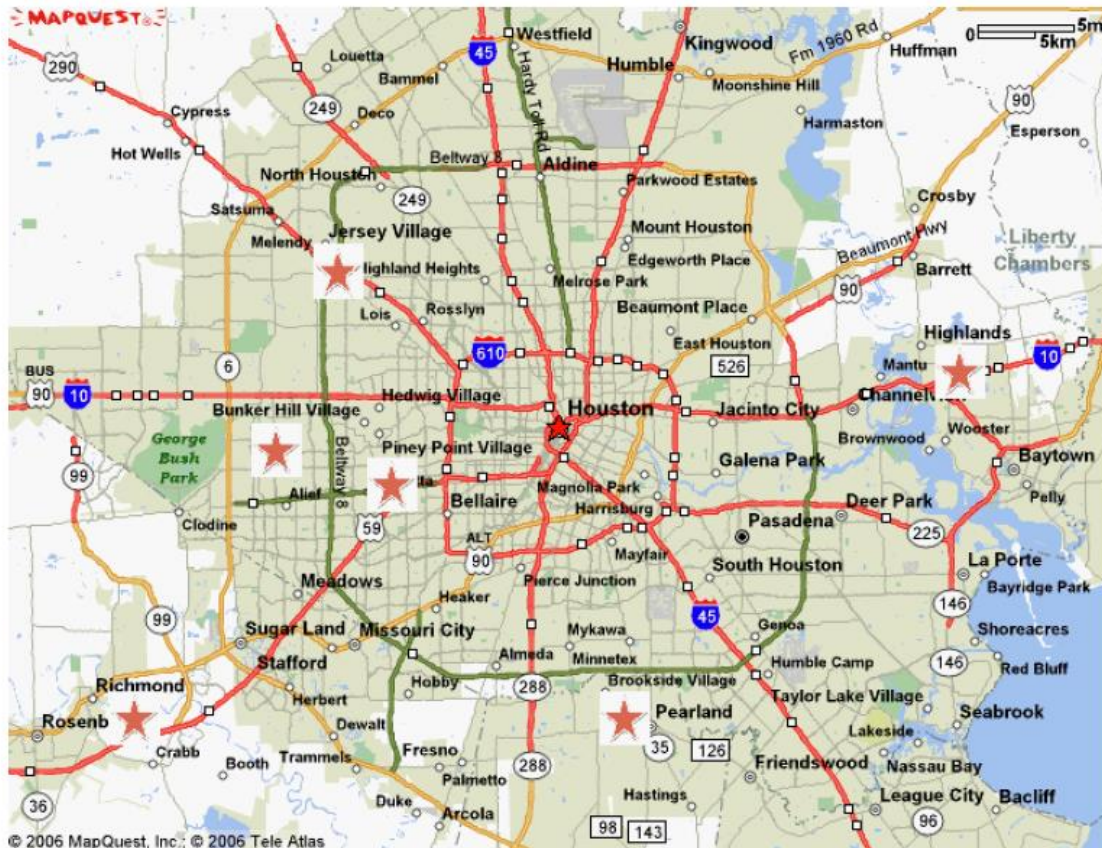


Figure 7. Construction site locations in Houston

The basic scenario developed by van Vleet. Significant advances have occurred with the web site; however, van Vleet established all of the critical factors for the game. The timing of each round of the game, representing a week, was set at 20 minutes, with 15 minutes of bid time and 5 minutes of construction time. One subsequent game modelled on a ten-minute week proved to be a disaster to play as a game and this idea

was abandoned. Stable economic conditions are assumed to exist for the duration of the work. A game generally takes from three to four hours. Each game has eight to nine rounds of play, each round model a week in a real world scenario, but for efficient play is modelled as a twenty minute interval. The interval has fifteen minutes of play or bidding time and five minutes for recovery.

Table 4 shows the location names for the six sites and the distance from the purchaser's main office location in Sugarland.

Table 4

Location of the construction sites in Houston

Site #	Location of Development	Distance from Sugarland (kilometres)
1	Brookside Village	41.6
2	Piney Point Village	24
3	Highlands	70.4
4	Jersey Village	40
5	Bunker Hill Village	27.2
6	Richmond	14.4

Table 5 shows the site development costs for each of the locations. The base cost for the slab is \$10,000.

Table 5

Site development costs for each slab

Site #	Travel Cost (\$)	Delivery Cost (\$)	Total Cost(\$)
1	858	624	1482
2	495	360	855
3	1452	1056	2508
4	825	600	1425
5	561	408	969
6	297	216	513

As Guhya (2010) noted the work is repetitive, as is usual for a production homebuilder, which simplifies the production process. In almost all of the research work to date, new players have been introduced for each game, as the research has focussed on the development of the player's ability in the early stages of the game.

The key assumption is that each Monday, the owner, termed the v player, posts the jobs that they are going to start that week. The data included is where each job is located. In the game play, the owners post the job offers and all the related information (like the location of the jobs, estimated cost of the jobs, etc) on the ASP based website (Kingsley-Hughes, Kingsley-Hughes, & Read, 2004) every Monday, and then all the bidders log on to the web site and starting bidding for the jobs.

Table 6 lists the default variables for the Reverse Auction Bidding web site. The production builder builds only one type of home and hence requires each contractor to pour only one type of slab. All λ_i players have been prequalified and only price matters, as is normal in this type of bidding system. An upper limit of 3.5 times the base cost is set as the maximum allowed by the game. This derives from a study of the base and range of sales prices for soft drink. A lower limit of 0.9 times the base cost is set as a minimum allowed by the game, unless the bidder elects to bid lower and confirms the bid. This rule was introduced to catch typing mistakes, such as a bidder bid offer of \$1,500 instead of \$15,000, as the purchaser does not want bankrupt subcontractors. The rule is also to enforce the bank's requirements of a reasonable return in a stable economic environment. Bidding period is 15 minutes per game, so there is a limit to the number of bids in the period (Yuan, 2013).

Table 6

van Vleet's default variables for game

Component	Unit	Amount
Bank account of each contractor at start of the game	\$	40,000
Job cost	\$	10,000 for the slab cost, travel costs, delivery charges
Total time of competition	Weeks	8
Maximum work capacity at outset of the game	Jobs	3
Loan amount for adding bid capacity	\$	500
Each job contract time	Days	5
Work week	Days	6 (Monday to Saturday)
Chances of rain delay	Percent	30
Construction cost accrued	-	Daily
Payment for work	Day	5 th
Bidding time	Minutes	15

One of the variables used in the game is rainfall. Rain on too many days on a working site during a week can delay completion and reduce the bidder's capacity in the following week. Houston has relatively high rainfall from May to July every year. The game was assumed to play during this period, as this is when the first game occurred. Delay caused by rainfall was taken into account in this game. National Oceanic and Atmospheric Administration (NOAA, 2010) provides the data on the statistical information for the probability of rain in Houston for the months of May, June and July. The point is to introduce a random element to the game. Figure 8 depicts the rain distribution for this area

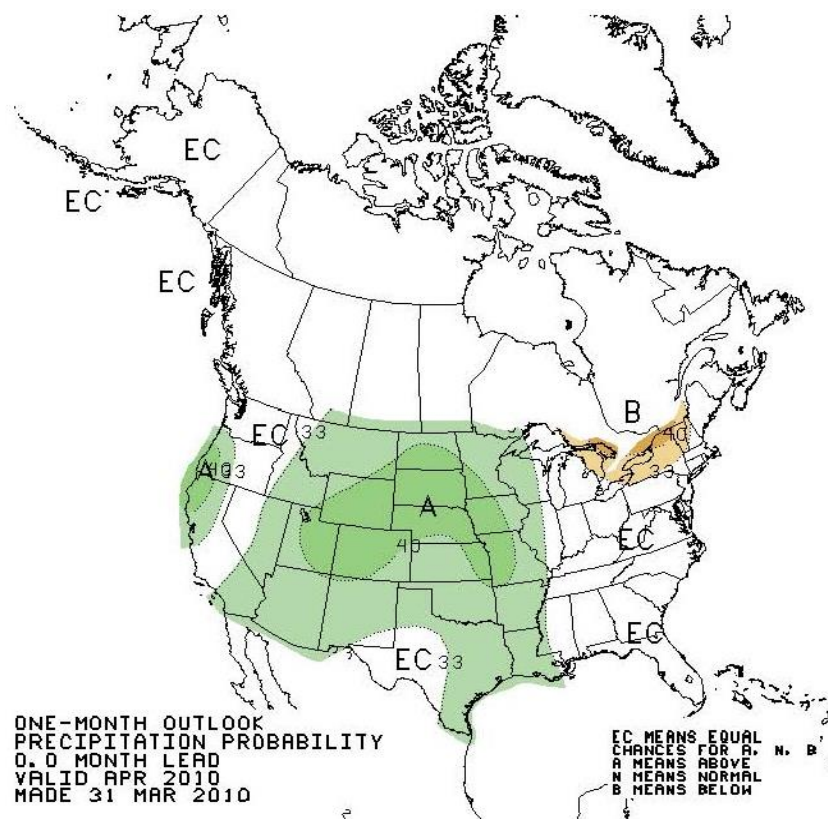


Figure 8. Rain probability in USA after NOAA (2010)

If rain occurs on two days of the week on one of the awarded contracts sites for the week, then the contractor's capacity in the following week is reduced by one. Table 7 represents the form of the rain delay matrix on each of the site location used in the case studies. "1" denotes enough rainfall to cause a delay in construction, whereas "0" denotes no rainfall. Currently there is no correlation between the site locations and the amount of rainfall in that vicinity.

Table 7

Rain Delays for week one

Day	Site					
	One	Two	Three	Four	Five	Six
Monday	1	0	0	0	1	0
Tuesday	0	1	1	0	0	0
Wednesday	0	0	0	0	0	0
Thursday	0	0	1	0	0	1
Friday	1	0	0	0	1	1
Saturday	0	0	0	0	0	0

Figure 9 shows the login page of TAMU Reverse Auction Bidding system, each participants will have their own username and password to login.

Figure 10 shows a sample data collection screen. If the bidding on this round is not over, then all other bidders have the opportunity to bid at lower price to win the job.

Reverse Auction Bidding Game

Now: Day 1107 (Monday), Week: 159

Login to the Game

11:07 PM 4/5/12

Time Details

Current Start Date: Thursday, April 05, 2012

Notice

This site is designed to undertake research into Game Theory for Reverse Auction Bidding.

Principal Investigator is John Nichols, (jm-nichols@tamu.edu),
Associate Professor in the Department of Construction Science

Login

User Name: Password:

Department of Construction Science

Texas A&M University - [Software Version: February 28, 2012]

Technical Problems, then please send email to [Web Admin](#).

Institutional Review Board matters about the research, mail to [IRB](#).

This game is best played on the OPERA Web Browser.)

Figure 9. Reverse Auction Bidding login screen

The screen shows that the participant at week 4 with one completed jobs and four jobs in process. The participant also holds the lowest price for two bids ongoing now.

A mechanism was provided for each bidder to increase their capacity to bid as shown in Figure 11 .

The main aim of the game is to observe the development in course of game and the of competition variation in the game. Competition is introduced in two forms, the first by the purchaser providing a different number of jobs per week. Each participant has a capacity to bid for three jobs, which means three slabs per week, provided there is no rain. This means that the four players each have 25% of the market share. The corresponding Herfindahl index is 2500. The players compete for jobs.

Driver Co.'s Reverse Auction Bidding - MY BIDS' INFORMATION

[\[ALL CURRENT BIDS\]](#) [\[ALL COMPLETED JOBS\]](#) [\[MY BIDS INFO\]](#) [\[LOGOUT\]](#)

Now: Day 22 (Monday), Week: 4

My Active Bids

JOB#	LOCATION	CURRENT PRICE	CURRENT BIDDER	TIME REMAINING	MY LOWEST BID AMOUNT	OUTBID
14	Woodlands	\$ 100000	Driver Co.	806 seconds.	\$ 100000	
15	Kingwood	\$ 100000	Driver Co.	806 seconds.	\$ 100000	

My Jobs in Progress

JOB#	LOCATION	Bid Amount	Job Start Date	Delays	Construction days	Cost to Date
8	Gleanloch farms	\$ 100000	Day 16	3 days	4 days	\$ 8600
9	Kingwood	\$ 100000	Day 16	3 days	4 days	\$ 8740
10	Sugarland	\$ 100000	Day 16	3 days	4 days	\$ 9200
11	Gleanloch farms	\$ 100000	Day 16	3 days	4 days	\$ 8600

My Completed jobs

Job#	Site	Bid Date	Bid Amount	Cost	Profit	Start day	End day	Rainy days	Profit Rate
5	Woodlands	Day 8	\$ 49999	\$ 11325	\$ 38674	Day 9	Day 15	Day 2	77.35%

My summary

- Current Spare Capacity For Additional Work : 2 [Your total capacity : 6 (Initial capacity : 3, Added capacity by bank guarantee : 3)]
- Current Financial Condition : \$ 41034 (No money paid to initiate work, No money paid in middle of job)
[= Capital money [\$40000] + Profits from completed jobs - Costs of current jobs in progress - Bank Guarantee Fee(\$500/loan)]
Current My Total Bank Guarantee Fee : \$ 2500

Figure 10. Reverse Auction Bidding - sample data screen

Notice

- Click the job number or current price of active bids to check the bid history of each jobs.
- Remember your initial job capacity is only 3. You cannot bid anymore if your capacity is over, without taking out a loan at \$500 per site per contract.
- Refresh your browser or click [\[ALL CURRENT BIDS\]](#) button frequently during the bid time to check updated current bid prices.
- * "Ept." means "Expected".
- Bids start on the 10, 30 and 50 minute times for **2106 jobs**. Bidding Time is 15 minutes.
- You have a clock, but remember your clock may be different to the server clock and you need to allow for this fact.
- The tab [\[MY BIDS INFO\]](#) can take 1:30 minutes to refresh. Be warned.

**Currently your capacity is full including current winning bids and jobs in progress.
You cannot bid at this time.**

If you ask for a Bank Guarantee, you can increase your capacity. Bank Guarantee fee is \$500 per guarantee. Do you want?

Figure 11. Bank loan screen

The players do have an option to add additional project capacity; the term used is a bank loan and this term is used for historical reasons. A payment of \$500 as fee to the bank increases the capacity of the bidder for one week by one job. Previous research has shown this is a powerful tool for winning more work (Gupta, 2010). A simple analysis

based on the Herfindahl Index equation shows the relative change in the market strength of the players who take out bank loans.

Data Structure

There are twenty four research studies completed by previous master's students at TAMU. Eight high quality data sets were used for this analysis. Table 8 summarizes the detailed information about the data sets used in this analysis. Other sets were discarded because of issues including, ten players in the game and owner's interference in the play.

Table 8

Study list

Study No	Student Name	Participants
1	Van Vleet	5
4	Gujarathi	4
9	Saigaonkar	4
11	Gupta	4
12	Patel	4
14	Plumber	4
15	Bedekar	4
16	Katakam	4

Table 9 shows a sample of the bid data taken from the first study. The data is stored during the game in a SQL Server database. There are a total of six tables in the database. SQL-Table 1 holds the log data for the people logged onto the computer system. SQL-Table 2 holds the company names and login details. A company name is

given to each player so that their confidentiality is maintained during the game. SQL-

Table 3 holds the job data, including start and end times.

Table 9

Bid Data - Sample after van Vleet (2004)

Bid ID	Job ID	Ctr ID	Bid Amount	Bid Date	Bid Time	Bid Status
1	1	9	\$15,000.00	1	7:00:20 PM	0
2	1	8	\$13,000.00	1	7:00:22 PM	0
3	3	9	\$12,000.00	1	7:00:31 PM	0
4	2	8	\$14,000.00	1	7:00:53 PM	0
5	1	4	\$12,999.00	1	7:01:02 PM	0
6	4	4	\$20,000.00	1	7:01:25 PM	0
7	12	6	\$12,825.00	1	7:01:28 PM	0
8	2	7	\$13,500.00	1	7:01:29 PM	0
9	5	9	\$12,000.00	1	7:01:34 PM	0
10	4	7	\$15,000.00	1	7:01:36 PM	0
11	1	8	\$12,500.00	1	7:01:39 PM	0
12	4	7	\$14,000.00	1	7:01:48 PM	0
13	7	8	\$16,000.00	1	7:01:50 PM	0
14	2	7	\$13,000.00	1	7:01:54 PM	0
15	11	4	\$12,700.00	1	7:01:58 PM	0
16	13	6	\$20,000.00	1	7:01:59 PM	0
17	6	8	\$12,500.00	1	7:02:06 PM	0
18	4	4	\$13,999.00	1	7:02:14 PM	0
19	1	4	\$12,400.00	1	7:02:21 PM	0

The numbers of jobs per week are determined using a set of die. SQL-Table 4 holds the bid data as shown below on Table 9. SQL-Table 5 holds the weather delay data and SQL-Table 6 holds the summary of the construction details. A number of integer flags are used to control data flow because a web site is essentially stateless (Paz, 2013).

The stored data is:

- Bid Id consecutive integer

- Job Id Job number applied to a particular site and day
- Ctr Id Bidder Identity number used for the program
- Bid Amount Offer
- Bid Date Each week is numbered, 1, 2, 3 etc...
- Bid Time Time that the bid is offered by the bidder
- Bid Status Reserved for program use

Table 10 shows a sample of the control data used for the game. The data is in four groups:

- Identity Number used to record all details in the SQL Server database as the key identity. Five is reserved for system use
- Name, Logon Name and Password. The logon name is usually a simple name such as shown here and does not link to the actual player
- Capacity current weekly capacity
- Loan amount and the amount taken in bank loans

It is suggested for future research purposes that the loan data include the timing of the loan data, so that the impact during particular rounds of the games can be studied effectively. The weekly capacity is recalculated at the end of each week to allow for rain and non-completion of some jobs and at the time of taking out a bank loan.

Table 10

Reverse Auction Bidding control data

ID	Name	Username	Password	Capacity	Loan
1	Doc	Beith	Butcher	3	\$0.00
2	Grumpy	Coll	WillGrimm	3	\$0.00
3	Happy	Duir	HalfPint	3	\$0.00
4	Sleepy	Gort	Napoleon	3	\$4,000.00
5	Reserved for system use				
6	Bashful	Muir	Grub	3	\$2,500.00
7	Sneezy	Nion	Chuck	3	\$8,500.00
8	Dopey	Quert	Wolf	3	\$2,000.00
9	Stealthy	Gus	Lenny	3	\$11,000.00

Table 11 shows an example of the job and profit details. The data columns are:

- Control ID the contract number to identify each unique job
- ID player identity number, if 5 then not awarded
- Job ID the job identity number in the job list, some jobs may not be awarded
- Cost for the job including base, travel, delivery and site costs
- Profit for the job as a gross profit
- Delay number of days of delay in the job due to rain

- UC reserved for system use
- Begin Date are numbered 1, 2, 3, etc. so a week is seven days, commencing with Day 1 as a Monday, Sunday is observed as a day of rest as is common in the construction industry
- End Date at the end of the contract, if equation 4 is true then there has been no impact on the capacity due to rain

$$EndDate - BeginDate = 4 \quad (3)$$

Table 11

Profit and job data

Control	ID	Job	Cost	Profit	Delay	UC	Begin	End
1	4	1	\$10,350.00	\$1,650.00	0	5	2	6
2	4	5	\$10,350.00	\$1,400.00	0	5	2	6
3	9	13	\$10,000.00	\$900.00	0	5	2	6
4	7	2	\$10,450.00	\$1,650.00	1	5	2	7
5	4	3	\$10,450.00	\$1,549.00	1	5	2	7
6	6	4	\$10,450.00	\$1,550.00	1	5	2	7
7	7	7	\$10,700.00	\$1,600.00	2	5	2	8

Petersen (2010) studied the performance of ξ bidders. The bid amounts for this game are shown on Figure 12.

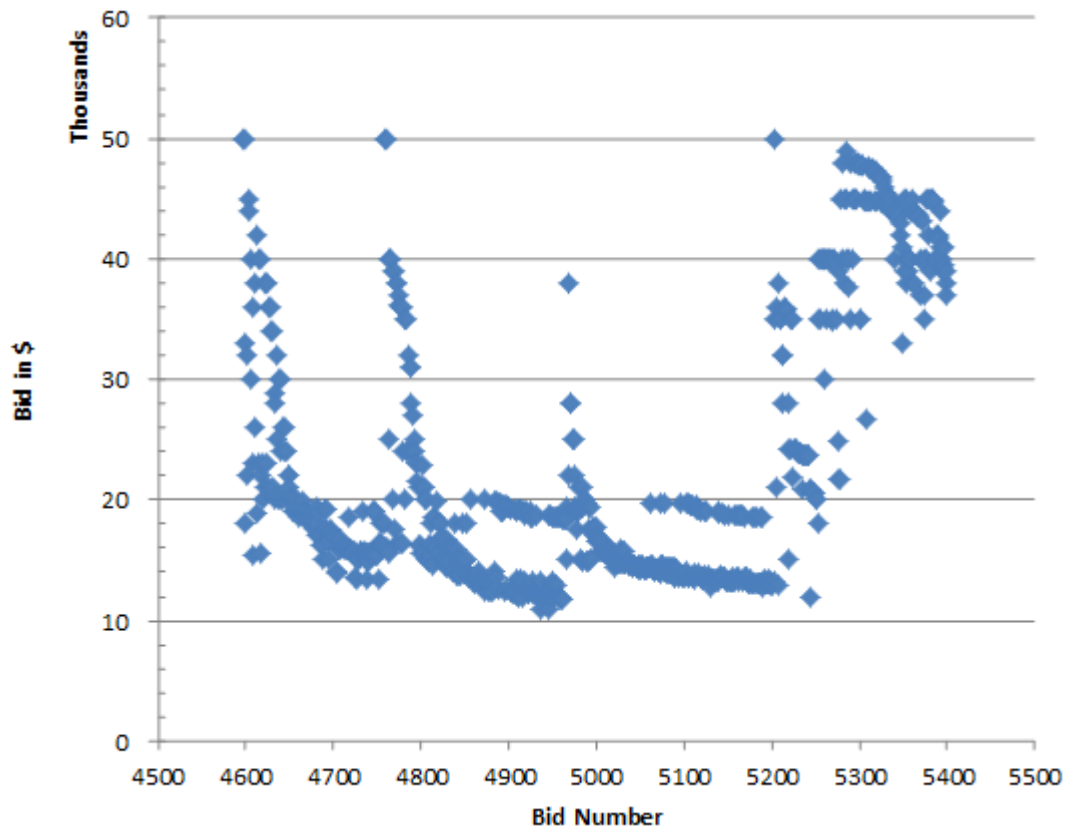


Figure 12. Bid distribution from RAB study 10 after Petersen (2010)

Data Analysis

Guhya (2010) developed a number of the techniques used for the analysis of the Reverse Auction Bidding data, based on the work of the earlier researchers. The first stage in the data analysis is to sort the bid data for each different bidder. *Figure 12* shows a sample of the bid data from RAB Study Number 10 (Petersen, 2010).

Table 12

Game 10 bid data sample

Bid Number	Job Number	Participant	Bid Amount
4750	1368	4	15450
4741	1368	2	15550
4733	1368	4	15582
4730	1368	2	15600
4713	1368	4	15850
4710	1368	2	16000
4708	1368	4	16750
4707	1368	2	16800
4701	1368	4	16890
4700	1368	1	17000
4698	1368	4	17400
4696	1368	2	17500
4691	1368	4	17520
4675	1368	2	18000
4661	1368	4	18500
4653	1368	2	19000
4643	1368	6	19999
4619	1368	2	20000

The data of interest is the bid reduction at each step of the play. This data can be collected from a sorted data set.

The price reduction data is collected and then sorted into different bin range: between 1 and 10, between 10 and 100, between 100 and 1000, between 1000 and 10,000, and 10,000 above. Figure 13 shows the counts of the number of bid drops made by Participant 1 in RAB Research Number Four.

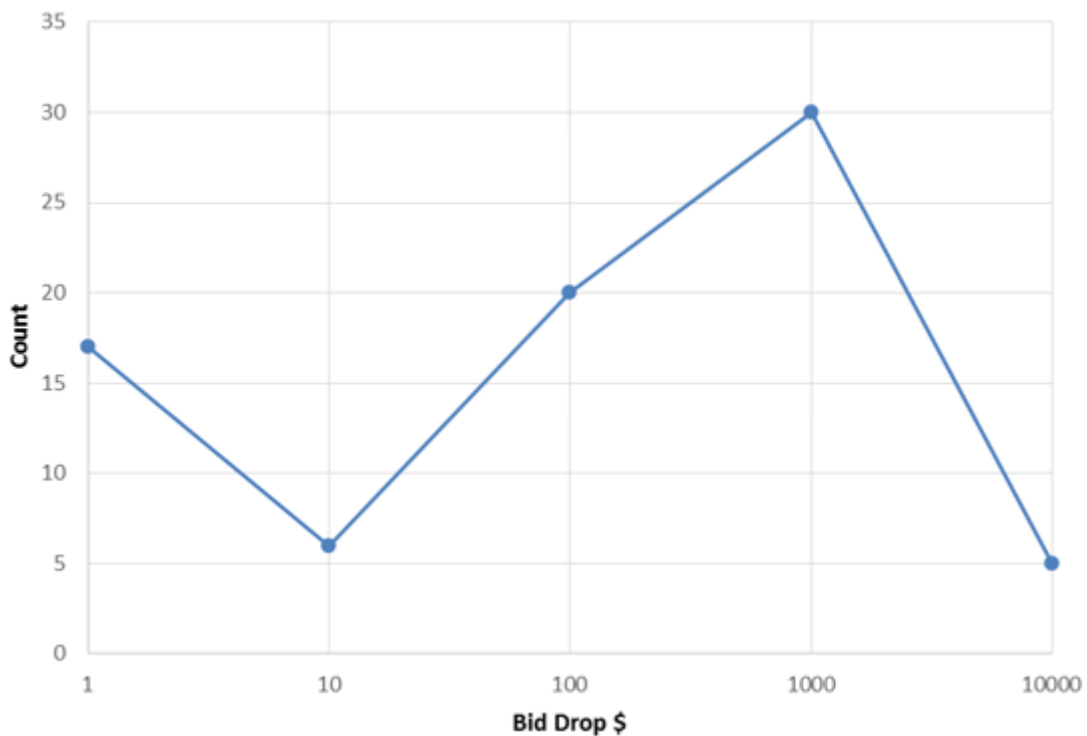


Figure 13. Frequency of different profit loss level

Figure 13 also shows that the bidder reduced the total bid group by \$82,077. This represents a significant portion of the available profits.

CHAPTER IV

RESULTS

Introduction

This chapter provides a comparison between the results for previous studies and the new findings. The sections of the chapter are:

- Summary of the Studied Data
- Findings

Summary of the Study Data

The research work is based on a group of the Reverse Auction bidding games completed at Texas A&M University since 2004. Table 13 lists the studies used in this work.

Table 13 shows the study number, which relates to the order of the studies in the overall research work, the number of participants, the number of bids, the maximum bid and the minimum bid. These games are played by new bidders in each game, although a player was once used twice.

Figure 14 shows a plot of the bid data for the original study by van Vleet (2004)

Table 13

Study results summary

Study No	Participants	Number of Bids	Maximum Bid	Minimum Bid	Winning Bidder ID
1	5	698	\$1,200,000	\$2,000	9
4	4	347	\$300,000	\$133,335	3
9	4	903	\$60,000	\$12,898	12
11	4	865	\$62,000	\$11,700	2
12	4	759	\$64,000	\$12,499	1
14	4	1282	\$60,416	\$12,000	4
15	4	708	\$35,000	\$11,800	1
16	4	403	\$64,000	\$11,900	1

The other observation of importance in Table 13 is the variation in the bid maximums. The results point to the need for the conceptual development of the upper limit to the bid price. An upper bid limit was introduced by Gujarathi (2008) to provide an upper limit price point to match the real world limits. The limit is 3.5 times the base price including the travelling and delivery costs. The travelling and delivery costs were recently adjusted upward to reflect current cost conditions. This idea stems from the reasonable concept that the purchaser has the economic sense to understand values that are economically excessive (Hartford, 2005).

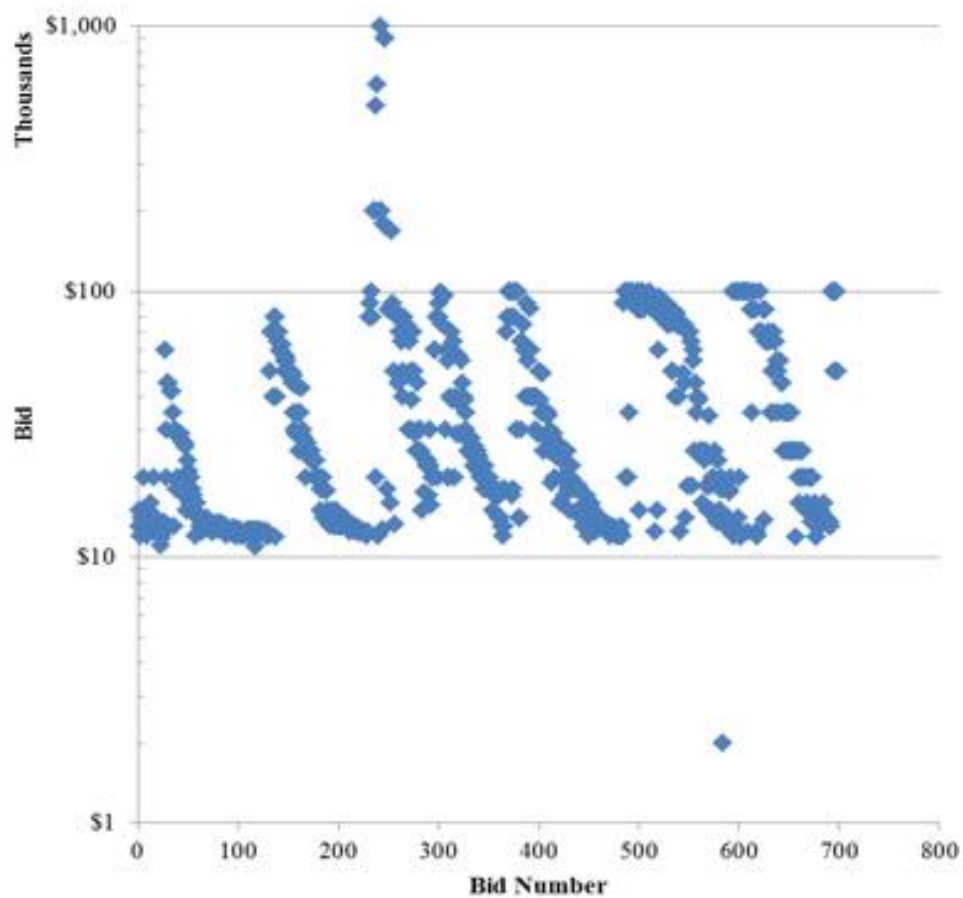


Figure 14. Study number 1 - bid data

Figure 14 shows the early stage of low bids, which was studied and formalized by Chouhan (2009). The \$2000 bid at a time when the average bid is \$20,000 shows the problem of typing errors, this is the type of error that will lead to a court case or a broken relationship as most small contractors cannot absorb such a loss. This issue was fixed with the introduction of the check on low prices. There is also a bid limit of 0.9 times the base costs; this is in place to catch typing errors that would otherwise spoil the game data. Occasionally bid data includes losses instead of profits. Dharamshi (2014) recently

completed a three game study; the 24th study in this research set. The third game in Dharamshi's study shows atypical results including a number of losses and unusual profit levels. This game will be discarded for future analysis.

Figure 15 shows the number of bids per job for each of the jobs in this research.

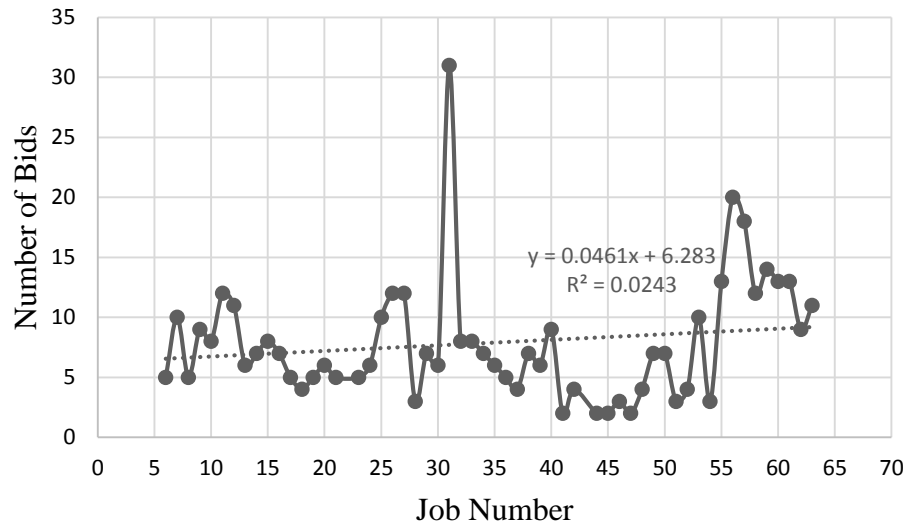


Figure 15. Number of bids per job

The crucial observations are the issue of flagging interest between job number 15 through 24 and 40 through 54, the high number of bids in the early game play, which leads to an erosion of profit. This observation on flagging interest has led to the standard eight round game, which based on an average of 7 to 8 jobs per game yields about 50 to 60 jobs in each game.

In studying the profits levels between games, the method developed by Guhya (2010) was to normalize the profit using equation (1). Guhya's method is applied to the profit on each job.

Dharamshi (2014) studied the total profits obtained by each participant in three games to establish a more formal definition for the Type ξ , Type ζ and Type ϕ bidders. He used a standard 8 round game to define a Type ξ , as one who averaged 18% of the available profit, a Type ζ player as one who averaged 2% of the available profit and a Type ϕ player as one who averaged about 9% of the total profit. One of the suggested indicators for poor performance is making significant reductions in the offered price, the rules of the game only require a reduction of one cent to make a valid bid, and anything more is essentially wasted profit in terms of the λ player. The λ player is a symbolic assignment, but poor average performance ultimately affects all bidders.

The variable of interest is then moved to the bid drop or reduction in the price. Figure 16 shows a histogram plot of the binned bid reductions for the fourth study (Gujarathi, 2008).

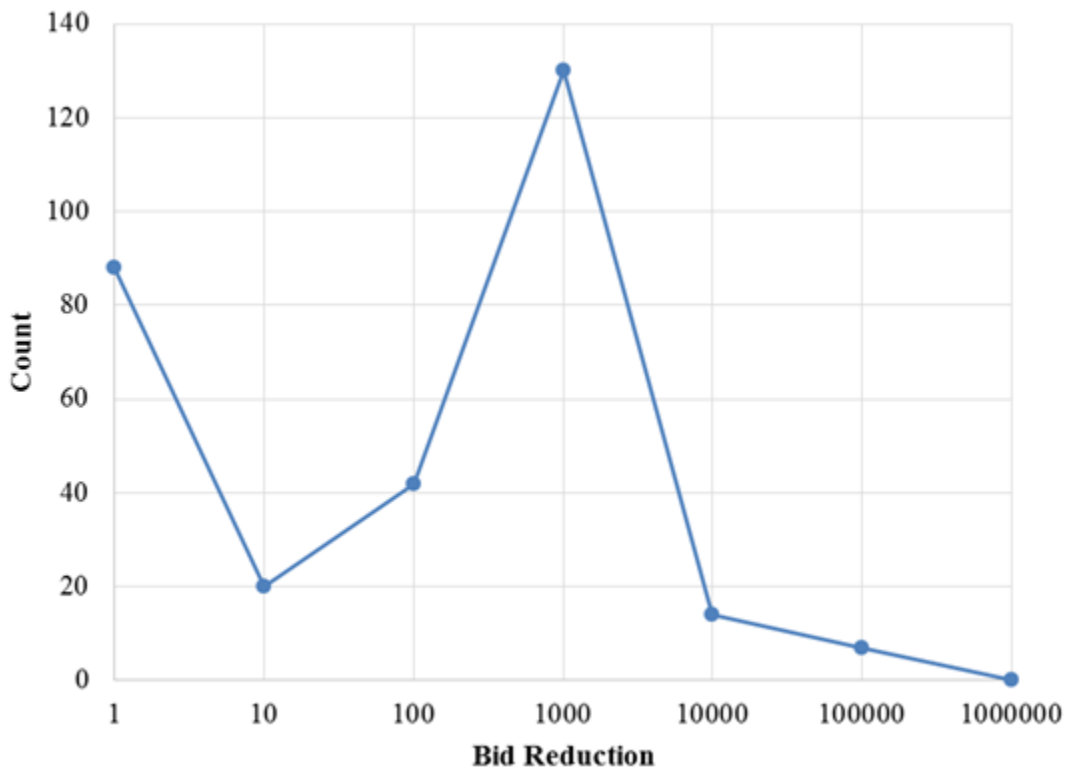


Figure 16. RAB Study 4 – bid reduction binned amounts

Figure 17 shows the bid amounts plotted against the bid numbers for RAB Study 4. Figure 17 shows the issue with the binning procedure, the maximum drop in price is 18,000, which does not fit into the 10,000 bin, but is included in the 100,000 bin. Figure 19 shows the complete bid drop data plotted as a histogram for the set of studies used in this research.

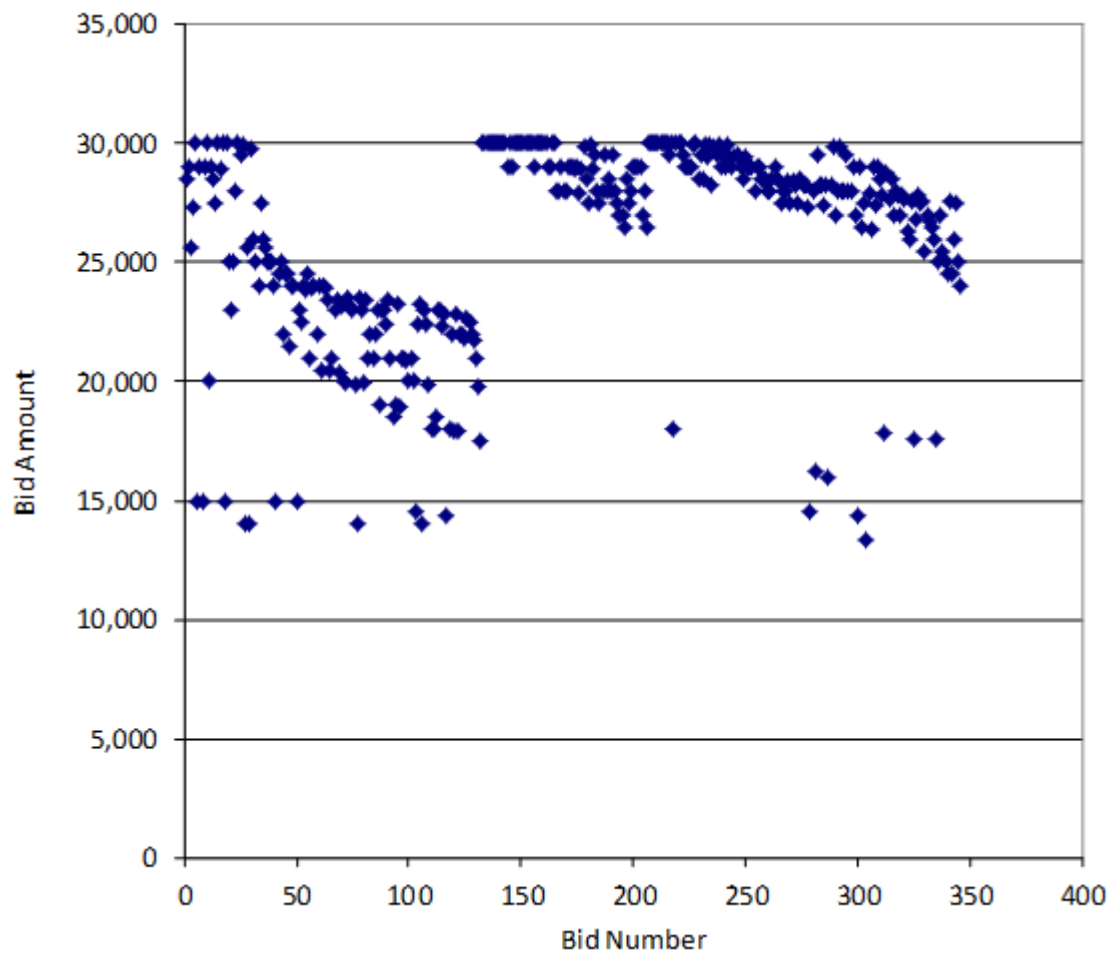


Figure 17. RAB Study 4 - bid amounts

In this research the outcomes of the game shows that in the early stage the bid participants were competitive and bided amongst each other to obtain project rather than making profit. During course of the game players switched between competitive zone and non-competitive zone (profit zone).

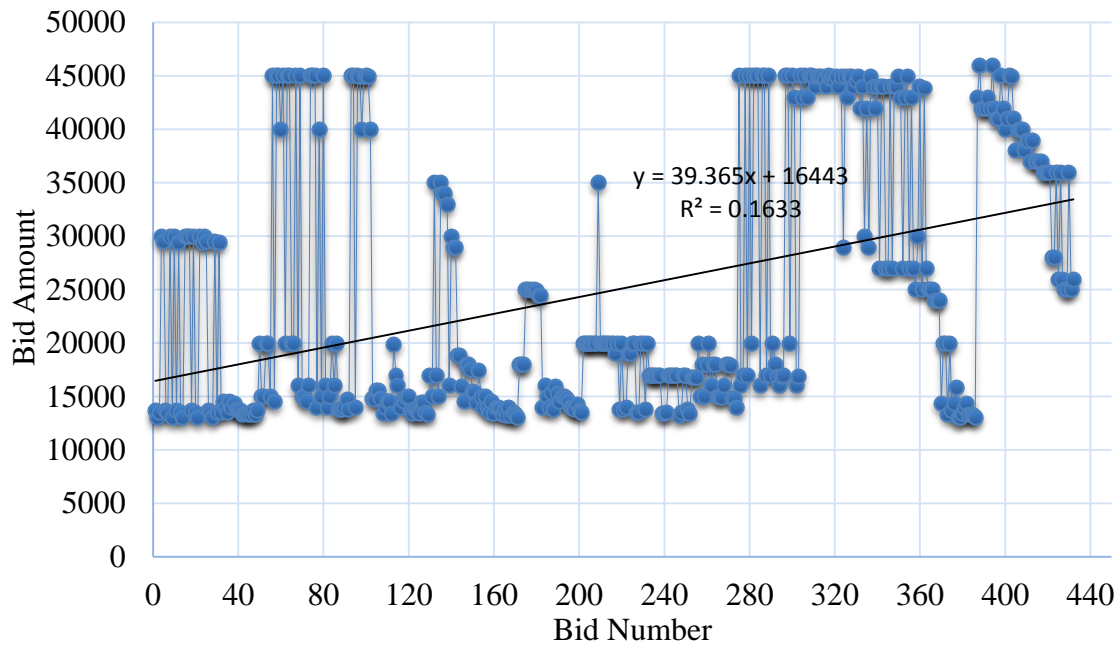


Figure 18. RAB study - bid amounts

Figure 18 shows the trend observed in this study. This study suggests that few of the participants realized the fact that being competitive reduces or eliminates chances of profit and thus, tried to control game by bidding high amounts initially. Some of the other participants followed while others were still in competitive zone and slashed bids by high values and decreasing profits for the contractors and satisfying the owner's requirements of low bid.

It almost took 8 rounds of game play to investigate, being in competitive zone only leads to profit erosion and thus, each bidder changed to non-competitive zone. After the switch bidders started making profit by making small drops in bid amount at a time rather than accelerated drops in the bid amount.

After few rounds of game, each player decided not to compete with other player and started to make profit. Bids of the game shows that players initiated making small bid drops rather than going for accelerated drop in bid amount..

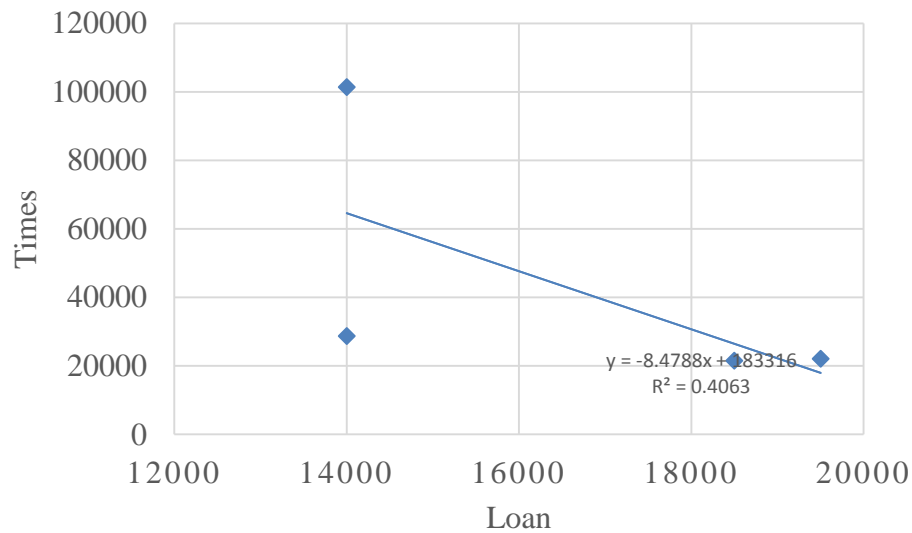


Figure 19. Profit and loan trends for current study

Figure 19 shows the relation between profit and the loan trends. Previous studies suggests that the bidder with higher loan amounts gain maximum profit. This study has a slight deviation from previous trends. In this study the person with lower amount of loans were able to make maximum profits. In this study bidders seeking loans were not able to perform as intended and bidder with low loans were able to outdo bidders with high loan amounts.

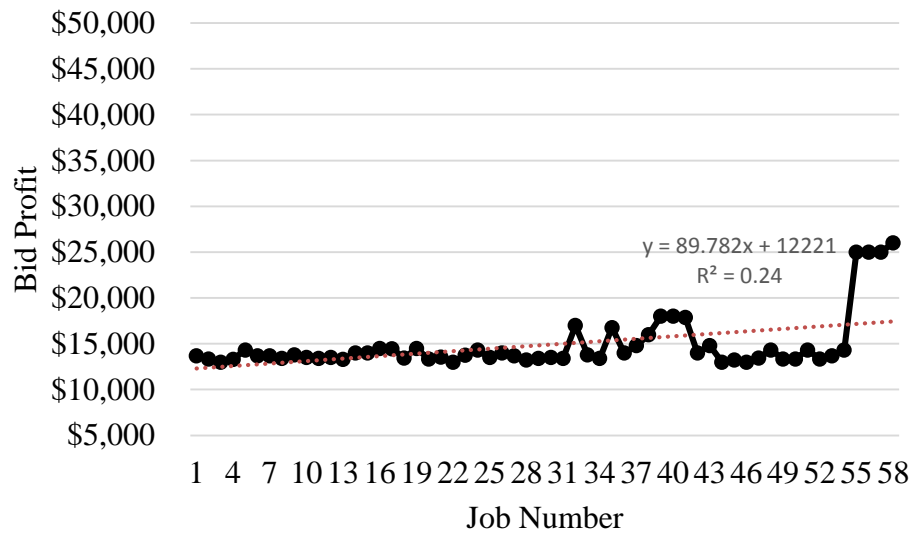


Figure 20. Bid Profits in each Job

The research conducted shows that initially all the bidders tried to win jobs by bidding the projects for low amount and then during the course of game players started bidding carefully. Bidders started to bid higher than owner's expectations. This supports the results of the previous studies. Figure 20 shows the similar trend shown in previous studies.

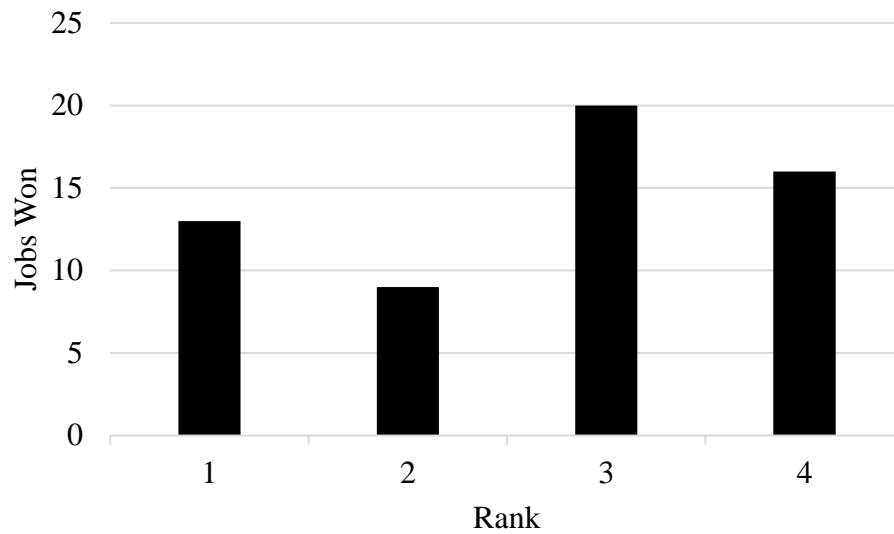


Figure 21. Rank in accordance to number of jobs won

In Figure 21 the ranks are in accordance to the profit each individual made. So the individual with rank one made maximum profit in the game and rank 4 made the least profit.

Previous studies show that the bidder with higher no of contracts awarded gain maximum profit. This study the general trend is not observed in this study. The person with 13 bids contracts made more profit than the person who won 16 bids.

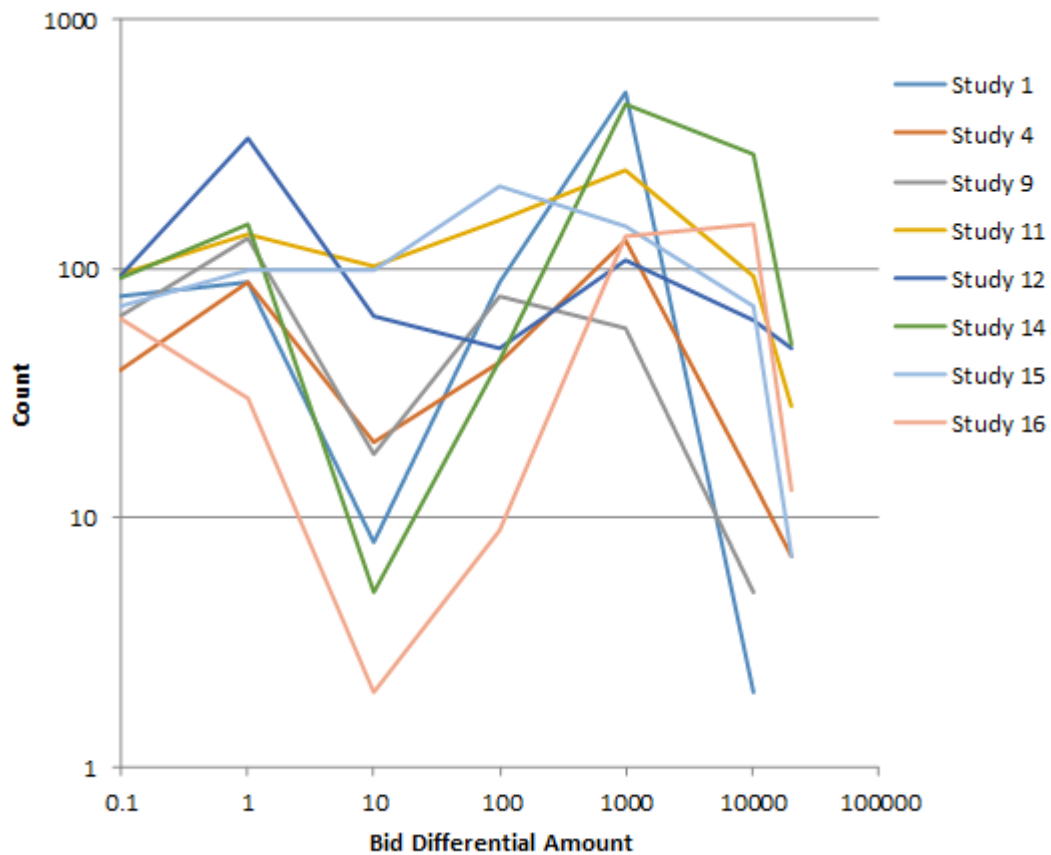


Figure 22. Bid differential data - all studies

Feigenbaum (2014) opined that a strategy existed to beat the bidders who lowered by only a low amount, such as one dollar. The same is been observed in this study. The bids were reduced by amounts as low as \$ 1. The strategy is to make a bid that is significantly lower, so as to signal that the bidder is aggressive and the strategic bidder seeks profits elsewhere. This pattern search is a separate study.

CHAPTER V

CONCLUSION

A formal study of the Reverse Auction Bidding System commenced in 2004 at Texas A&M. van Vleet, who led the first study, was interested in collusion. Since this research, numerous studies have been done, with most showing similar results, and slowly adding to the database of performance in the Reverse Auction Bidding game.

This research project into Reverse Auction Bidding is the first of the twenty four studies completed to this time to use an individual with personality type Idealist specifically against other personality types. Most of the previous case studies used students at Texas A&M University as the subjects of study and in one study industry professionals were used. Amongst all previous studies, result of one of the study showed that personality type Idealist win over personality type Guardian and it was the first where this unexpected result were observed. This research study is used to verify the previous finding that an Idealist performs better than a Guardian, as Guardians are the usual winners in this game study.

Reverse Auction Bidding is a new form of bidding using the internet as the bidding tool. In this type of bidding the buyer and a set of sellers adopt a slightly different role than in Forward Auction. In this case study, a purchaser requests bids through a web based system or a web site. Invited bidders can respond under a standard set of timed conditions to the bidding documents on the web site. This research program has a SQL Server based web site. House slabs in Houston area are assumed to be

projects and are placed online and bids ought from prequalified sellers. There are those that see the Reverse Auction bidding system as a new and some think revolutionary step into a modern system. An alternative view that has not yet been tested is the concept that the Reverse Auction Bidding system represents a condensation of the demand and supply chain problem into a smaller time than occurs in oldest economic models. In the oldest economic models, goods are offered for sale at the start of the season at the highest prices, the demand matches the price and goods are sold. If the goods all sell in a fraction of the total season the seller has underestimated the price to demand curve, if however a few goods are left over the seller has overestimated the price to demand curve in mathematical sense only. If on the last day of the season at the ninth hour the seller disposes of all of the goods at the selling price at the start of the season then one has achieved some form of stable equilibrium, although it may not be a maximization of profit point. In the Reverse Auction bidding system the supply and demand curves are visible for all, the only entity that can determine the price once the bids are called are the interaction between the electronic system and the bidders. Each bidder has a unique set of requirements placed on the bidder by the surrounding economic environment as is clearly shown in the work of the undercover economist. The bidders offer a range of prices, if the price system is somewhat stable the bidders make one offer and realize they have maximized their profit, if all jobs are filled and there is no excess capacity, then why lower prices. van Vleet, without realizing the impact, however introduced a bank loan system. In reality it is not a loan, but a fee, an entry fee for an additional unit, the fee represents five percent of the total cost. Clearly the fee impacts on the relative

capacities of the bidders and alters the supply to demand curves; in almost all circumstances the use of bank loans results in increased profits. The interesting ethical issues in this system are set aside for this study, but they are worth future consideration, one could argue, perhaps successfully, that this represents some form of cronyism, or perhaps not.

This study of The Reverse Auction Bidding method used four students from the Department of Construction Science at Texas A&M University as the subjects of the work. The specific details of the game are that each bidder has capacity to bid on three jobs at any time. A bidder can buy additional capacity from the bank to increase the number of allowed simultaneous bids. All bidders initially have a bank cash amount of \$40,000, which is considered reasonable for a small company in a stable market. Each game lasts for twenty minutes, fifteen minutes of game play followed by a five minute break. The game occurs in stable economic circumstances, the supply and demand curves are set by the game and the bidders. The four bidders have a total capacity of twelve jobs per week, which can be increased with loans. If all take out loans equally then supply rises equally, but if they use loans unequally then supply rises unequally in relative terms. The purchaser is aware of the twelve job limit and attempts to manipulate prices by limiting the jobs to less than thirteen per week, in this case the study team use a set of two dice to determine the number of jobs per game. The distribution characteristics have been studied elsewhere. The results from earlier games show that three types of bidders exist. The long term recent research has focused on determining the properties of the three different bidders and this is now tolerably understood.

In each study, each individual participant was given a personality test, Keirsey Temperament Sorter Test. The research question for the entire study is now to determine if personality impacts or predetermines the three different types of bidders.

All the participants were identified to be Guardians. There was no individual with personality type Idealist. This is possible because of low proportion of Idealists' in general. The original hypothesis looked to determine the impact of Idealists, but as will all research one must deal with the hand dealt. The study of four Guardians is in itself of interest and tolerably rare event, so the study looked at four Guardians. The implicit hypothesis in this study is that Guardians should all be economically efficient bidders.

Relative profits during this experiment matched the pattern from those of past experiments. Individuals learn to make money during the game play session and start to bid strategically to make profit. It has been observed that at the starting benefits are low and start to expand with time because of the learning during the game. As the participants know the game better the returns grow and this learning affects owner's savings.

However, when the game play was completed, all of the profit percentages for the participants were very low. It has been observed that when Guardians play against other personality type they outperform the game and make maximum returns and are economically efficient, but when Guardians play against each other the profit drops significantly. This is an interesting problem, why do Guardians perform poorly against other Guardians should be the subject of further research. The further question is can a poor economic performer be created by the personality of the other bidders.

The next stage is to look to the sub-groups within the Guardian personality type. The bidders with characteristic property ISTJ according to the Test, or also called Inspector, were more competitive than other Guardians. The Inspector made sufficient profit to be classified as average economically, but not efficient. The bidder who made the most aggressive use of the bank loan did not perform as expected.

Initially each participant has a bidding capacity of \$40,000 which is sufficient to bid only for three jobs at a time. If the bidder wants to bid on more than three jobs it can increase its bidding capacity by taking loan from bank with a minimal fee payment of \$500. More jobs to bid might fetch more project contracts and thus signifies more profit. In this study bank credit consumption rate was a key marker of performance as has been observed in previous studies. However the returns for this study varied from past studies. Loan and profits were not linearly related. This observation leads to some speculation that cautious bidder with low credit could be more effective than other dynamic bidders.

This game was atypical in terms of the results; it may be as a result of the personality impacts. Further work is recommended to understand the behavior difference and bid pattern for sub categories of Guardians. Further work is also recommended on the supply and demand issues.

The hypothesis could not be tested as none of the participant in the current study were identified to be personality type Idealist. The personality type Idealist are said to be rare and thus we were unable to get any Idealist in the game. All the participants in this study were identified to be Guardians. As known each personality can be subcategorized

and thus we identified Guardians in their subcategory and analyzed the data and this should be observed closely. Further work is required on this aspect of the game play.

With advances in technology making everyday life easier, the same occurs for the Reverse Auction Bidding game and its researchers. For instance in this study, data was gathered from four different participants in four different locations Technologies have made the process of collecting data and conducting the experiment easier, which in the future will allow students and instructors to gather data twenty-four hours a day and seven days a week, which will provide an enormous amount of information to more precisely match personalities and successful bidders.

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APPENDIX A

THE KEIRSEY TEMPERAMENT SORTER

For each question, decide on answer a or b and put a check mark in the proper column of the answer sheet. Scoring directions are provided. There is no right or wrong answers since about half the population agrees with whatever answer you choose.

1. When the phone rings do you
 - a. hurry to get to it first
 - b. hope someone will answer
2. Are you more
 - a. observant than introspective
 - b. introspective than observant
3. Is it worse to
 - a. have your head in the clouds
 - b. be in a rut
4. With people are you usually more
 - a. firm than gentle
 - b. gentle than firm
5. Are you more comfortable in making
 - a. critical judgments
 - b. value judgments
6. Is clutter in the workplace something you

- a. take time to straighten up
 - b. tolerate pretty well
7. Is it your way to
- a. make up your mind quickly
 - b. pick and choose at some length
8. Waiting in line, do you often
- a. chat with others
 - b. stick to business
9. Are you more
- a. sensible than ideational
 - b. ideational than sensible
10. Are you more interested in
- a. what is actual
 - b. what is possible
11. In making up your mind are you more likely
- a. to go by data
 - b. to go by desires
12. In sizing up others do you tend to be
- a. objective and impersonal
 - b. friendly and personal
13. Do you prefer contracts to be
- a. signed, sealed, and delivered

- b. settled on a handshake
14. Are you more satisfied having
- a. a finished product
 - b. work in progress
15. At a party, do you
- a. interact with many, even strangers
 - b. interact with a few friends
16. Do you tend to be more
- a. factual than speculative
 - b. speculative than factual
17. Do you like writers who
- a. say what they mean
 - b. use metaphors and symbolism
18. Which appeals to you more:
- a. consistency of thought
 - b. harmonious relationships
19. If you must disappoint someone are you
- a. usually frank and straightforward
 - b. warm and considerate
20. On the job do you want your activities
- a. scheduled
 - b. unscheduled

21. Do you more often prefer
- a. final, unalterable statements
 - b. tentative, preliminary statements
22. Does interacting with strangers
- a. energize you
 - b. tax your reserves
23. Facts
- a. speak for themselves
 - b. illustrate principles
24. Do you find visionaries and theorists
- a. somewhat annoying
 - b. rather fascinating
25. In a heated discussion, do you
- a. stick to your guns
 - b. look for common ground
26. Is it better to be
- a. Just
 - b. merciful
27. At work, is it more natural for you to
- a. point out mistakes
 - b. try to please others
28. Are you more comfortable

- a. after a decision
 - b. before a decision
29. Do you tend to
- a. say right out what's on your mind
 - b. keep your ears open
30. Common sense is
- a. usually reliable
 - b. frequently questionable
31. Children often do not
- a. make themselves useful enough
 - b. exercise their fantasy enough
32. When in charge of others do you tend to be
- a. firm and unbending
 - b. forgiving and lenient
33. Are you more often
- a. a cool-headed person
 - b. a warm-hearted person
34. Are you prone to
- a. nailing things down
 - b. exploring the possibilities
35. In most situations are you more
- a. deliberate than spontaneous

- b. spontaneous than deliberate
36. Do you think of yourself as
- a. an outgoing person
 - b. a private person
37. Are you more frequently
- a. a practical sort of person
 - b. a fanciful sort of person
38. Do you speak more in
- a. particulars than generalities
 - b. generalities than particular
39. Which is more of a compliment:
- a. "There's a logical person"
 - b. "There's a sentimental person"
40. Which rules you more
- a. your thoughts
 - b. your feelings
41. When finishing a job, do you like to
- a. tie up all the loose ends
 - b. move on to something else
42. Do you prefer to work
- a. to deadlines
 - b. just whenever

43. Are you the kind of person who
- a. is rather talkative
 - b. doesn't miss much
44. Are you inclined to take what is said
- a. more literally
 - b. more figuratively
45. Do you more often see
- a. what's right in front of you
 - b. what can only be imagined
46. Is it worse to be
- a. softy
 - b. hard-nosed
47. In trying circumstances are you sometimes
- a. too unsympathetic
 - b. too sympathetic
48. Do you tend to choose
- a. rather carefully
 - b. somewhat impulsively
49. Are you inclined to be more
- a. hurried than leisurely
 - b. leisurely than hurried
50. At work do you tend to

- a. be sociable with your colleagues
 - b. keep more to yourself
51. Are you more likely to trust
- a. your experiences
 - b. your conceptions
52. Are you more inclined to feel
- a. down to earth
 - b. somewhat removed
53. Do you think of yourself as a
- a. tough-minded person
 - b. tender-hearted person
54. Do you value in yourself more that you are
- a. reasonable
 - b. devoted
55. Do you usually want things
- a. settled and decided
 - b. just penciled in
56. Would you say you are more
- a. serious and determined
 - b. easy going
57. Do you consider yourself
- a. a good conversationalist

- b. a good listener
58. Do you prize in yourself
- a. a strong hold on reality
 - b. a vivid imagination
59. Are you drawn more to
- a. fundamentals
 - b. overtones
60. Which seems the greater fault
- a. to be too compassionate
 - b. to be too dispassionate
61. Are you swayed more by
- a. convincing evidence
 - b. a touching appeal
62. Do you feel better about
- a. coming to closure
 - b. keeping your options open
63. Is it preferable mostly to
- a. make sure things are arranged
 - b. just let things happen naturally
64. Are you inclined to be
- a. easy to approach
 - b. somewhat reserved

65. In stories do you prefer
- a. action and adventure
 - b. fantasy and heroism
66. Is it easier for you to
- a. put others to good use
 - b. identify with others
67. Which do you wish more for yourself:
- a. strength of will
 - b. strength of emotion
68. Do you see yourself as basically
- a. thick-skinned
 - b. thin-skinned
69. Do you tend to notice
- a. disorderliness
 - b. opportunities for change
70. Are you more
- a. routinized than whimsical
 - b. whimsical than routinized

APPENDIX B

KIERSEY TEMPERAMENT SORTER SCORING

Enter a check for each answer in the column for a or b.

[illegible]

Directions for Scoring

The directions for scoring the test are:

1. **Add down** so that the total number of a answers is written in the box at the bottom of each column. Do the same for the b answers you have checked. Each of the 14 boxes should have a number in it.
2. **Transfer the number** in box #1 of the answer grid to box #1 below the answer grid. Do this for box # 2 as well. Note, however, that you have two numbers for boxes 3 through 8. Bring down the first number for each box beneath the second, as indicated by the arrows. Now add all the pairs of numbers and enter the total in the boxes below the answer grid, so each box has only one number.
3. **Now you have** four pairs of numbers. Circle the letter below the larger numbers of each pair. If the two numbers of any pair are equal, then circle neither, but put a large X below them and circle it.